THE NEW POTATO CULTURE

As developed by the Trench System, by the judicious use of Chemical Fertilizers, and by the Experiments carried on at the Rural Grounds during the past sixteen years.

BY

ELBERT S. CARMAN,

Editor of THE RURAL NEW-YORKER, Originator of the Trench System and of the Potatoes Nos. 1, 2 and 3.

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TO MY FRIEND

SIR JOHN BENNET LAWES

BART., LL. D., F. R. S., F. C. S.,

THIS LITTLE VOLUME IS

RESPECTFULLY AND AFFECTIONATELY INSCRIBED

BY PRIVATE LETTER,

BY HIS NOBLE EXAMPLE, AND BY MANY CONTRIBUTIONS TO THE JOURNAL I HAVE EDITED DURING THE PAST FIFTEEN YEARS, HE HAS ENCOURAGED AND INSPIRED ME TO TRY TO DO AS HE HAS DONE, THOUGH WITH FEEBLE SUCCESS.

E. S. C.

THE RURAL NEW-YORKER.

AMERICAN GARDENING.

OUT-DOOR BOOKS.

INTRODUCTORY.

FOR the past fifteen years, during the growing season, I have given a part of my time to potato experimentation, in the hope that I might throw some additional light upon the various questions involved in the central problem, "How to increase the yield without proportionately increasing the *cost* of production." It often happened that, in the soil of my home grounds, some hills would yield enormously, while others would yield little. What was this owing to? What kind of manure or culture—what preparation of the soil would *insure* the maximum crop? Would stable or cow manure, hen manure, or a compost of the three? Would lime, plaster, salt, muck, wood ashes, muriate or sulphate of potash, bone, phosphatic rock, fish, flesh, blood, sulphate of ammonia, nitrate of soda, separately or in any combination, effect this? Would it be possible so to fit the soil as materially to increase the yield? What would be the best depth to plant the seed? How much seed should be planted—single eyes, two, three, or four eyes; half potatoes, whole potatoes, stem-ends or seed-ends? Should the manure or fertilizer be placed *under* or *over*, and how much should be used? Should the soil be *firmed* or rendered as loose and friable as possible?

These were the individual questions suggesting themselves which made up the central problem, "How can we increase the yield of potatoes without proportionately increasing the cost of production?"

As experiments were carried on from year to year, it was found that the yield from this experiment plot was increased at the rate of from 100 to 600 bushels to the acre; that portions yielded at the rate of over 1,000; that certain hills and certain varieties, treated apparently the same as the rest, yielded over 1,500 bushels to the acre. Would it be *possible* to ascertain what the exact conditions were which gave such yields? Would it be possible to approach them on *acres* instead of *plots? Would it be possible to furnish equivalent conditions to acres in an economical way?*

The reader who has the patience to consider with some care the following pages, may judge for himself whether any approach to a positive answer has been made by the results of the work herein placed before him.

River Edge, Bergen County, New Jersey.

CONTENTS.

PAGE

CHAPTER I 13

The Origin of the Trench System of Raising Potatoes. The "Potato Contest." How it Came About. The "Contest" Plot. The Planting Begun and Finished. The Fertilizer Used. The Trenches. How far Apart. Hilling up Avoided. The Varieties Planted. Notes of Progress. A Perfect Stand. Incessant Rains. The First Intimation of Something Wrong. The Vines Die Prematurely. Applications of Various Insecticides. The Cucumber Flea-beetle Discovered to be the Cause. Not Confined to any Limited District. Previously Attributed to "Blight." Insecticides of no Effect to Kill the Insect—But they Hurt the Vines. Previous Treatment of the "Contest" Plot. The Result. The Plot Measured by the Committee. Yield of the Several Seedlings. No. 3 Failed. Otherwise the Yield would have Exceeded the Rate of 700 Bushels to the Acre. Report of the Judges.

CHAPTER II 20

Failures, but Instructive Failures, The Second "Contest" Plot. Modifications. Favorable Conditions in Every Way. Notes of Progress. Flea-beetles in Great Numbers. All Sorts of Insecticides Used Without Avail. Foliage Injured. The Kinds Planted. Premature Death of the Vines. The Yield. The Tubers not Half Grown, and a Large Proportion Decayed.

CHAPTER III.. 24

Another Failure on a Larger Scale, with its Teachings. Learn by Failures as well as by Successes. A Half-acre Trial on a Poor Soil. General Opinion that such Large Yields cannot be Produced on Extended Areas. May we not Double our Crops without Doubling the Cost of Raising them? The Enemies of Great Yields. Potatoes Checked in their Growth never Yield Maximum Crops. The Fitting of the Half Acre. Plowed in the Fall and Potash and Phosphoric Acid Applied. Why Nitrogen was not Applied in the Fall. The Trenches Depth to Plant. Covering. Conservation of Moisture. Hilling-up to be Avoided. Why. Shallow Cultivation. Spring Work. A

PAGE

Late, Cold, Wet Spring. An Injudicious Decision. Additional Fertilizers Applied. Frost-bitten Seed. One-eye Pieces Planted of Necessity. Number of Potatoes to the Barrel. The Kinds Planted. The Mulch. The Forms and Quantity of Nitrogen Applied. Partial Failure of the Seed. The Yield. The Cost.

CHAPTER IV 31

Mr. Terry's Views. Expectations not Realized. The Yields from Small Plots Deceptive. Mr. Minch's Great Yields Queried. The Author's Yields due to other Causes than the Trenches. Mr. Terry cannot see any Benefit from the Use of Fertilizers on his Land. The Advantages of Level Cultivation Set Forth. Fewer Green Potatoes. Reply to Mr. Terry. Evident reasons why as Large Crops cannot be Raised on Acres as on Selected Plots. Just as much to be Learned from Trials on Small as on Considerable Areas. The Small Plot may tell us Just what the Acre Needs. Why Farmers Prefer to "Hill-up." How Trenches Direct the Rainfall. Mr. Minch Explains. The Economy of Large Quantities of Manure.

CHAPTER V 39

Some Heavy Yields by the Trench Method. The "Women's National Potato Contest." Over 1,000 Entries. Prizes Awarded. The Yields of the Prize-takers. The Trench System takes the First Prize in a full Acre Contest. The Prize won was $1,100—the Yield was 738 Bushels.

CHAPTER VI 42

Conservation of Moisture. Importance of Rainfall. Ineffectiveness of American Experiment Station Work. Sir J. B. Lawes. When and How first Induced to Write for the American Farm Press. Governmental Action Precipitated thereby in the matter of Establishing Experiment Stations. Fundamental Weakness of American Stations as at Present Conducted. Political Influences. "Available" rather than "Capable" men too often Chosen as Officers. Uncertain Tenure of Office. Conducting the same Experiments Year after Year Impracticable. Farmers are Solicited to Try the Effects of Mulching in a Small Way. Objections to the Trench Answered. Treading on the Seed Pieces Condemned. Roots do not Issue from the Seed. Seed Potatoes, unlike true Seed, need a Loose, Mellow Soil.

CHAPTER VII 47

Experiments with Different Fertilizers, First Season. Single or Special Fertilizers. Fertilizers should not be Condemned because Fertilizer Constituents, used Separately, fail to Increase the Crop. How to Find Out what your Land Needs. The Elements Deficient in the Soil must be Supplied. Wherein Fertilizers Differ from Manure The Needs of this Particular

PAGE

Soil Plainly Shown. The Soil will Answer Questions if put in the Right Way. The Natural Soil Yields. The Specially Fertilized Soil Yields. The Complete Fertilized Soil Yields. Tables and Comparisons. Second Season's Trial on different Land with the same Fertilizers and Fertilizer Constituents. A Soil that will "Not Grow Beans" without Manure. A Hungry Soil. Tables. A Summary of Results. Third Season's Trial on a Change of Plots with Essentially the same Fertilizers and Fertilizer Constituents. To what Extent do Small or Thrifty Tops Correspond to the Crop of Potatoes? Ratings Rarely Fail to Indicate. When they (the Ratings) do Fail. Well Balanced Fertilizers never give a Luxuriant Growth of Vines without a Corresponding Growth of Tubers. Better Land than that of Preceding Trials and more Variable Results. The Land still Replies: "Give Me All Kinds of Food." A Letter from Sir J. B. Lawes respecting the Effects of Different Fertilizers. Artificial Fertilizers Profitable, if Judiciously Applied, in Potato Culture. Nine crops of Potatoes in succession Grown at Rothamsted. The Kinds and Amounts Fed. The Results of Nitrate Nitrogen and Ammonia Nitrogen the Same. The Loss of Nitrogen and the Necessity of a Liberal Supply. The Results of Mineral Fertilizers alone only One-half those when Nitrogen is Added. The Quantity of Potash Required is very Large. The Color of the Leaves and Stems as Affected by Nitrogen, by Minerals and by Both. Explanation. A Larger Crop of Potatoes Obtained with Minerals alone than with Nitrogen alone. Wheat an Exception. Why. Instructive Tables; Study them. The Minerals may Remain for Future Crops—the Nitrogen is Lost. Results of Experiments made at Rothamsted on the Growth of Potatoes for Twelve Years in Succession on the Same Land, as set forth by Dr. Gilbert. Twelve Years of Potato Culture without any Manure or Fertilizer. The Yield as Great, under this Exhaustive Treatment, as the Average Yield of the United States. Nitrogenous Manures alone Barely Increase the Yield. The Slow Action of Farm-yard Manure. The Marked Effects of an Addition of Nitrogen to Farm-yard Manure. Disease does not Increase by Continued Growth from Season to Season. Specific Gravity of the Potato an Indication of Quality. Cook Potatoes with their Skins on.

CHAPTER VIII 69

The Effects of Different Quantities of "Complete" Fertilizers on Potatoes. Fertilizers against Manure. Telling Effects of Fertilizers on Potatoes. They Increase the Yield more than does Stable Manure. Trial upon One-tenth of an Acre that had not been Manured in 15 Years. Smoother Potatoes from the Fertilizer. The Vital Question which each Farmer must Solve for Himself or be Left Behind in the Procession. The Yields from 220, 440, 880, 1,320, 1,760, 2,200 pounds of Fertilizer to the Acre. Sulphate of Iron Harmful. Averages. A Difference of over 138 Bushels per Acre. In what Way is the Reader to turn the Results to His Own Advantage?

PAGE

CHAPTER IX 79

Shall the Fertilizer be placed *Under* or *Over* the Seed Pieces? Its Importance Depends on the Method of Culture. Tables. Averages. The Second Year Results. General Summary. The Difference in Favor of the Fertilizer *Over* 9.68 Bushels per Acre.

CHAPTER X 83

Results of Planting Potatoes in Trenches of Different Depths. First Trial. Planted from Two to Ten Inches Deep. Second Trial. Third Trial. Summary of Averages.

CHAPTER XI 87

Nitrogen, especially Nitrate Nitrogen as in Nitrate of Soda. Its Effects when Applied Alone. May Farmers derive a Profit from its Use when Applied to Land Indiscriminately or as Farm Manure is Applied? Joseph Harris's Views and the Author's Answer. Experiments. The Results, in a Partial Way, Justify Mr. Harris's Conclusions that the Average Potato Fertilizers of To-day are too Low in Nitrogen, in so far as this Particular Soil may be Taken as a Guide. See to it that the Land is well Supplied with Minerals, and then Add Increasing Doses of Nitrogen in an Experimental Way.

CHAPTER XII 100

Sundry Experiments. Potatoes Raised in Half Barrels. First, Pure Sand; Second, Garden Soil; Third, Three-quarters Garden Soil, One-quarter Cut Straw. Results. Experiment with Three Barrels. Barrels Half Filled, the Seed Potatoes Planted and Covered with a few Inches of Soil. As the Shoots Grow the Barrels are gradually Filled, Leaving the Seed Pieces 16 Inches Below the Surface. Where would the Tubers Form? The Root and Tuber-forming Growth. Blight. Results. Seed Potatoes Treated in Various Ways, and Fertilizers. Excessive Manuring. Effects of Salt. A New Way to Mulch Potatoes. "Valley Mulching." Pieces Placed on Top of the Soil and Covered with Mulch and Fertilized. Trenches Mulched, Fertilized and Not. Doubts Expressed as to Reported Yields. As High as "at the Rate" per Acre of over 1,800 Bushels, as Estimated from a few Hills. The easy Method of Computing Yields with Accuracy. The Best Distance Apart for "Single-eye" Seed. Different Number of Eyes to a Piece, from Single to Four Eyes to a piece. Different Sized Pieces without Regard to Number of Eyes. Experiments to Determine how Much Flesh each Eye should Have. Seed-end against Stem-end. Shall the Distance Apart, of the Seed Pieces Planted, be Proportionate to the Size of the Seed?

PAGE

CHAPTER XIII 115

Size of Seed. Generalizations. Habit of the Variety to be Considered. Small Seed of some Kinds—Large of Others. No Positive Rule can be Given. Illustrations. The Loss from Missing Hills. Underground Development. Relations between Few Eyes and Long Joints; Bushy and "Leggy" Vines. True Roots and Tuber-bearing Stems. Absurd Names. Seed and Stem Ends might more Properly be Called Tip and Butt, or Top and Bottom. Potato Growth. How Stems are Modified by Light and Air; by Soil and Moisture. Limiting the Space for the Growth of Nodes and Tubers.. Increase the Root System by Deeper Planting and a Mellow Soil. A Ten-story House may Occupy the same Ground Area as a One-story House. Again, as to the Size of Seed-pieces. Every Variety differs in Number and Potency of Eyes, and must be Cut and Planted Accordingly.

CHAPTER XIV 123

Analysis of the Tubers and Vines. The Effects of Special or Single Fertilizers, and in Various Combinations. The Effects of "Complete" Fertilizers. Stimulants. "Complete" Fertilizers not Necessarily Effective. A Familiar Talk with Farmers. Erroneous Conclusions as to Fertilizers. Why Farmers Condemn them. Food in the Soil, previously Inert, Rendered Available by Salt, Plaster, Lime, Etc. Forcing Land. Lashing it into Temporary Productiveness. "Complete" Fertilizers which Analyze the Same may Give very Different Results. Their Agricultural Value. Irrational Conclusions. How Money is Thrown Away. Farmers Conjured to use High-grade Fertilizers Adapted to the Needs of their Land. The Potato's Needs. The Difference. A Distinction without a Difference. Chemical Fertilizers are simply Concentrated Manures.

CHAPTER XV 135

Seedling Potatoes. How to Gather the Seeds, Plant them and Treat the Seedlings. Every Gardener and Farmer should Raise his Own Varieties. How to Select. Should we save Seed Potatoes from the most Productive Hills? Why the same Variety Varies. Millions of Dollars spent for New Varieties that might Just as Well have been Raised at Home. Seed Balls or Fruit. Selection of Seed. Glass Structures not Necessary. A Sunny Window will Do. How to Transplant. After care. Avoid any Poisonous Application. Mosquito Netting. How we should Select the Seedling Potatoes. Immature Seed will give a Degenerated Crop. Immature Cuttings will Produce Comparatively Feeble Plants. Bud Variation. Select Seedling Tubers of the Shape Desired. How Seedlings from the same Seed may Vary.

Page

CHAPTER XVI 144

Care of Seed. Exposing Sound Seed to Light and Sun Before Planting. How to Detect "Blind" Eyes. Lime as a Preserver. Handling. Poisoning. How a Perfect Stand may be Secured. The Views of Several Correspondents. The Importance of Shallow Cultivation and a Mellow Soil Emphasized. Paris Green. Mix it with Plaster, not with Water. Why! Absurdity of Picking off the Potato Beetles by Hand.

CHAPTER XVII 149

Experiments During a Dry Season and in a Variable Soil. First Series. Comparison of Nitrate of Soda with Nitrate of Potash. Vine Growth. Second Series. Comparison of Stockbridge with Nitrate of Soda. Vine Growth. Third Series. Comparison of Sulphate of Potash with Bradley. Vine Growth. Fourth Series. Comparison of Fertilized Trenches with Unfertilized. Vine Growth Fifth Series. Effects of Snuff as a Fertilizer. The Effects of Nitrogen, Phosphate and Potash, Used Separately and in Various Combinations. Vine Growth. Averages of Yield of the Several Nitrate of Soda Trenches.

CHAPTER XVIII 178

Another Talk About the Use and Effects of Chemical Fertilizers. A Maximum Crop of Potatoes Means an Ample Supply of Potato Food. Diluted Bordeaux Gives Unmistakable Benefits.

CHAPTER XIX 183

Miscellaneous. The Objections to Hilling-up. Mr. Hersey's Views as to Seed-end and Stem-end Seed: as to Shape, Answered. Brevities. Difficulty in Crossing Potato Flowers. Seed Sold by Seedmen as "Hybrid" Seed, not Hybrid. Hybrids Between the Alkekengi and Potato Sterile. Prof. Bailey's Experiments in Grafting the Potato on the Tomato, and *vice versa*. An Explanation of the Effects and Non-effects of Plasters. Questions and Answers. Killing the Tops Lessens the Yield. Keeping Potatoes. Largest Yielders. How Much Seed to the Acre? Does it Pay to Buy Fertilizer Constituents and Mix them at Home? Index.

CHAPTER I.

Origin of the Trench Method.

IN THE back part of our home grounds is a garden-plot of about an acre. When we built upon the property (two acres in all), nearly twenty years ago, it was designed that this garden-plot should be given to small fruits—grapes, strawberries, raspberries, blackberries, currants, etc.—around the borders, while upon the central area it was proposed to raise potatoes and other vegetables for family use. This was somewhat before I had thought of "experiment grounds" or had associated myself with the farm paper with which I soon after became and have since been connected. The soil was a mellow loam that might well be defined as "just right" or, in more specific description, one that, while retentive of moisture, was yet well drained and neither too much inclined to an impervious clay nor, on the other hand, to a leachy sand. Of the fertility of this soil, nothing was known further than that it had been cropped for many years without manure—fertilizers were practically unknown.

Our first season's essay proved to be a decided failure, though, in so far as we knew, our instructions were well carried out by the gardener. The potato "seed" (Early Rose) was planted in hills two by three feet apart without manure. The plot was fairly well cultivated, and the plants hilled-up according to the then popular way of raising potatoes. It was our hope (a confident hope, too,) to beat our neighbors, between whom, in the matter of all early vegetables, a friendly rivalry existed.

The tops grew vigorously enough, and anything like a failure of the tubers was not thought of. That this plot should have yielded not over seventy-five bushels to the acre is a fact that I have often pondered over, while anything like a satisfactory explanation has never

occurred to me. Assuming, at any rate, that this land was not over-well adapted to potatoes, their cultivation was not attempted for several seasons thereafter.

At length, having engaged in farm journalism, and desirous of testing the new varieties of potatoes then announced in unqualified terms of praise in the seedsmen's catalogues of the day, I determined to ascertain what *could* be done in this uncongenial soil, and the "*Trench System*" was among the first of the experiments which were suggested.

From that time until now this plot has been given to raising, in small trial-lots ranging from three or four to a dozen "hills," all the new varieties of which "seed" has been procurable. Probably the average number of trials during all these years would not be found to be less than seventy-five kinds for each season. The yields of these little lots varied remarkably—all the way from 150 to over 1,800 bushels to the acre. All were treated essentially alike, and reports were duly printed as to size, shape, color, yield and quality. The reports of the new kinds which gave a low yield were rarely made use of by the seedsmen, or others originating or introducing them, while the stupendous yields were given the most conspicuous publicity, greatly to my mortification in many cases. One of the most startling of these announcements declared that 1,391½ bushels per acre of the Green Mountain potato, had been raised by me. The truth was, that there were but *three* pieces (hills) planted, which yielded 17¼ lbs., or *at the rate* of 1,391.50 bushels to the acre! So it transpired that the anomalous yields reported from season to season were doubted by many good people, and it was to prove what the trench method was really capable of doing that a "contest" was announced, the results and every step of which were to be open to public investigation. Be it said here that I have never claimed that this method is preferable in all sorts of soils, for the excellent reason that I have not tried it in all sorts of soils. Reasoning from what is known of the potato during its period of growth, the trench system would *not* increase the yield in a sandy, leachy soil in which the level of the ground water is low, as nothing can be gained by rendering the soil less capable of securing the needed store of moisture through the osmotic action which the trench modification helps to assure in more retentive soils.

We have repeatedly, side by side, with and without fertilizer, tried this method and the usual way of raising potatoes, with the invariable

result that the trenches have given a decidedly larger yield. More than this, in our trials any decided increase of fertilizers, by the new method has given, as will be shown further on, a greater increase in yield than the same amount of fertilizer by the old way, which *of itself* is an important consideration. It shows that in the one case the plant is able to appropriate the food supplied to a better advantage than in the other.

Furthermore, as the results of liberal prizes offered in 1888 and again in 1889, it has been demonstrated that by far the heaviest yields on record have been produced by this method, which, in theory at any rate, seems to secure to the potato all that it needs in so far as it is in the power of man to do so.

HOW THE "CONTEST" CAME ABOUT.

During the winter of 1888 I made the statement in print that if I could not raise *at the rate* of over 700 bushels of potatoes to the acre on a given plot in my experiment grounds by what is known as the Rural Trench System of cultivation, let the season be favorable or unfavorable, I would forfeit $50 if any one would pay the same amount in case of my success—the money in either event to be donated for some charitable purpose. The challenge was accepted by Mr. Wilmer Atkinson, the editor of the *Farm Journal*, of Philadelphia, Pa.

THE "CONTEST" PLOT.

Owing to the lateness of the season, the "Contest" plot was not planted until April 20. The planting was begun at 7 A. M. At 8 A. M. a shower began which continued until the work was finished, causing the soil to become muddy on the surface. Previously (April 9th) the seed potatoes were spread out singly in a warm room. The eyes of the "seed end" soon pushed, forming short, warty shoots. The eyes of the other portions of the potatoes grew but slightly. The object in placing the seed potatoes in a warm, light room was to secure the most *vigorous* seed.

All potatoes, the eyes of which seemed dormant or feeble—"blind" as they are commonly called—were rejected. They were cut according to the number of strong eyes developed, the object being to have, at least, three to a piece. On April 18th, the trenches were dug with

a spade, about seven inches deep and a full foot in width. As we had not from experiments made determined whether it was better to strew the fertilizer *under* or *over* the "seed," it was sown both under and over. Eight hundred and eighty pounds were first evenly sown in the bottom of the trench, and incorporated with the soil by a Hexamer pronged hoe. On this, an inch or so of soil was raked, and the seed-pieces were placed exactly one foot apart, the trenches being three feet apart, measuring from the middle of each. These (the seed-pieces) were covered with another inch of soil, and powdered sulphur was scattered upon it at the rate of 400 pounds to the acre. Then an additional spread of the fertilizer (Mapes's Potato), at the rate of 880 pounds to the acre, was given, making in all 1,760 pounds to the acre. The trenches were then refilled with the soil taken out, which, being looser than the rest, left the soil of the trenches higher than that between them.

We have always been careful not to compact the trench soil any more than can be helped. The ridge left soon settles to the general level, and is so preserved during the season, as all hilling up is carefully avoided. The plot was planted to the following varieties—all seedlings of my own:

No. 2............33 pieces—one trench.
No. 3............66 " —two trenches.
No. 4........ ...66 " — " "

NOTES OF PROGRESS.

May 15th.—Up to this time the rain-fall had been all that was needed. No. 3 was the first to appear above ground; No. 4 next, and No. 2 last. Frost occurred the 17th, and cold, constant rains followed up to May 30th. The soil was drenched. Lima beans and melon seeds rotted in the ground. There was a perfect stand of potatoes in the "contest" plot. My note book of June 1st says: "Sifted Paris green and plaster—one pound of the poison to 200 pounds of the plaster. Soil compacted from incessant rains; frost this morning."

June 3d: "The plot cannot be cultivated *between* the plants because the tops meet and cover the soil."

June 8th: "No. 2 was the last to push its shoots above the soil, and

the plants were for some time smaller than those of the 3 and 4. At this time they have outgrown No. 3. All are growing thriftily."

THE FIRST INTIMATION OF SOMETHING WRONG.

June 17th: "The vines are now meeting, so that further cultivation between the trenches is impossible without injury to the vines. No. 3 vines are less thrifty than those of Nos. 2 or 4, and show signs of some weakness."

June 25th: "The No. 3 vines seem to be dying, from some cause which we cannot even guess at. One says 'it is a mole that has gone through the trenches;' another says 'it is a scald, owing to the terrible heat which followed upon a long term of cold, wet weather!' Another says 'it is the sulphur. You have given them too much.' The stems are weakly, the leaves yellowish. Some of the stems are turning black, and withering within an inch of the soil."

June 3d: "Gave another application of Paris-green and plaster."

After the above date all hope was lost of winning the contest. It was evident that No. 3 would be nearly a failure. The cause was discovered to be the

FLEA BEETLE,

known entomologically as *Haltica cucumeris*. The first suggestion came from our foreman, who said his own potato tops were dying, and that they were alive with fleas that were eating the leaves. "There are so many" said he, "that you can hear the noise they make when disturbed as I pass along the rows."

The writer had noticed while sifting plaster and Paris-green that these insects existed in unusual numbers, but it did not occur to him that they were the cause of the mischief. An examination of neighboring fields was made, and all were found to be injured more or less. Later, as the facts were published, accounts from many parts of the country were received showing that the pest was not confined to any limited section. Many who previously attributed the destruction of their potatoes to "blight" found that the flea beetle was really the culprit.

Soon after the No. 3 was hurt beyond recovery, the No. 4 was attacked, and finally the No. 2. We sprayed the vines with Buhach-

water, hellebore, Gishurst compound and Paris-green, but without the slightest helpful effect.

PREVIOUS TREATMENT OF THE CONTEST PLOT.

Potatoes had been raised on the piece of ground of which the "contest" plot was a part, for 12 consecutive years. It had never received much manure. The applications of fertilizers each year have averaged, no doubt, at the rate of 1,200 pounds to the acre, for the most part Mapes's Potato, with which, as with other brands, noted further on, I had been carrying on experiments of various kinds during the entire period, upon considerable areas as well as upon small plots.

Besides the potato fertilizer, the plot had received, at various times, small dressings of lime, wood ashes (leached and unleached), kainit and raw bone-flour.

THE RESULT.

Friday, the 28th of September, every member of the committee appointed to determine the yield was present, together with some 40 others from various parts of the country. Previous to digging the crop, the ground was carefully measured, to give accuracy to the computation.

The No. 4 yielded at the rate of 644 bushels per acre. The No. 2 yielded at the rate of 1,076 bushels to the acre. No. 3 was a comparative failure, owing to the vines having been destroyed by the flea beetle. The yield was only at the rate of 276 bushels to the acre. As this potato occupied two-fifths of the entire plot, the yield was thus reduced to below 700 bushels to the acre. It will appear to the reader and was evident to the judges and others who were present that, had the whole of the plot been planted with No. 2, the yield would largely have exceeded 700 bushels to the acre, and the contest would consequently have been decided in our favor.

REPORT OF THE JUDGES.

"We, the undersigned committee, having been appointed for the purpose of calculating the yield of potatoes grown upon the 'con-

test plot' at River Edge, Bergen county, N. J., do hereby certify that we saw the potatoes dug and measured the yield thereof. We found it to be at the rate of 583 bushels per acre."

Signed
PETER COLLIER,
W. A. STILES,
J. C. HAVILAND,
L. C. BENEDICT,
P. T. QUINN,
Committee.

Subscribed and sworn to this 28th of September, 1888, before me,

JOHN G. WEBB,
Justice of the Peace.

CHAPTER II.

Failures, but Instructive Failures.

HAD THE "Contest plot" been inaugurated a year or so before it was, there could have been little fear of failure. It was not until the *first* contest season that either blight or the flea beetle injured the crop materially. These devastators were, before that time, practically unknown.

A renewed effort was made the next year to produce at the rate of over 700 bushels to the acre. The wager of $200 was offered in our confidence that it could be done and, though the offer was widely published, there was not one to accept it, though, as in the first contest, the money was to have been given for some benevolent purpose.

THE SECOND CONTEST PLOT.

Trenches were dug April 6th, 10 inches deep and wide, 11 in number, each 33 feet long and three feet apart. Twenty-five pounds of the same potato fertilizer as previously used (1,000 pounds to the acre) were then sown broadcast, walking through the trenches—not *in* the trenches alone, but over the soil piled up between the trenches as well. The bottom of each trench was then loosened with a Hexamer pronged hoe. Five inches of soil were then raked back into the trenches and on this the seed-pieces (half of medium-sized potatoes with the seed-end cut off) were placed exactly one foot apart, making 33 in each trench, or 363 in the entire plot. Such large seed-pieces were never used before. The trenches were never before dug quite so deep and never before placed upon so great a depth of *mellow* soil. This work was done in a perfect manner, as the weather was fine and the soil in splendid condition to work. The trenches were filled, being careful to fill one at

a time and complete it so that the work could be done without walking on the completed trenches. Never was there a mellower seed-bed.

NOTES OF PROGRESS.

"May 7th.—To-day flea beetles were noticed in great numbers. Some of the plants were four inches high, others just breaking through. Sprayed all with tobacco soap dissolved in water, using two ounces to a pailful of water. Not effective.

"May 8th.—Sprayed the plants with water in which tobacco-stems had been boiled; also with whale-oil soap-water, one ounce to one gallon of water.

"May 9th.—Used Thymo-cresol and Paris-green and water. Corn cobs were dipped into crude carbolic acid and one placed between every two plants. Not effective in the least.

"May 10th.—A cyclone, attended with heavy rain. In the evening after the storm, as many flea beetles were noticed as before the storm.

"May 12th.—One tablespoonful of hellebore, one heaping tablespoonful of buhach, 25 drops of sulphuric acid, one teaspoonful of Paris-green to a pailful of water were sprayed on the vines. No effect.

"May 14th.—Two teaspoonsful of Thymo-cresol, a heaping teaspoonful of Paris-green to a pailful of water sprayed on the plants.

"The leaves now began to show some injury from these applications.

"May 17th.—Fleas thicker than ever. Applied Bordeaux Mixture on half the plot, and on the other aloes dissolved in hot water, four ounces to two gallons. The fleas seemed delighted with both.

"May 22d.—It was plainly to be seen that the R. N.-Y. No. 3 plants (second trench) were dying. It was decided to dig them up and plant 'Minister' instead. A few days after, several rows were dusted with unleached wood-ashes. The fleas the next day were not so numerous upon the dusted plants. They preferred the plants not dusted. Later the plants of the entire plot were first sprayed with water and then a mixture of the following was sifted upon them: Paris-green, two pounds, extended with one barrel of plaster; sifted unleached ashes; one-eighth pound of snuff, making in all a quarter of a barrel in the proportion of two-thirds ashes and one-third poisoned plaster. This was found to repel the fleas somewhat.

"June 16th.—Excessive rains up to this time. The vines have made a fine growth.

"July 23d.—Excessive rains up to this time. Soil saturated. Every variety is more or less injured by the flea beetle.

"July 30th.—Vines dying."

THE KINDS PLANTED.

Trench	No.	1	Seedling No. 2	33	pieces.
"	"	2	" No. 3	33	"
"	"	3	" No 4	33	"
"	"	4	" No. 4	33	"
"	"	5	" No 4	33	"
"	"	6	" No. 4	33	"
"	"	7	Brownell's Winner	33	"
"	"	8	Monroe County Prize	33	"
"	"	9	From J. H. Woodburn, Sterling, Ill.	11	"
"	"	9	New Queen	22	"
"	"	10	Seedling of Rose, from Thos. Lazell, Big Rapids, Mich	22	"
"	"	10	Tonhosks, from Theron Platt, Newtown, Conn	11	"
"	"	11	Brownell's Winner	33	"

THE YIELD.

No. 2 yielded 63 pounds, or at the rate of 454.66 bushels to the acre. They seemed to be about half grown. There were few rotten potatoes.

Minister yielded 32 pounds, or at the rate of 234.66 bushels to the acre. Many small; many rotten.

No. 4 (third row) yielded 53 pounds, or at the rate of 388.66 bushels to the acre. Many rotten; half grown.

No. 4 (fourth row) yielded the same as the preceding, 53 pounds.

No. 4 (fifth row) yielded the same within a fraction.

Brownell s Winner (seventh row) yielded 38 pounds, or at the rate of 278.66 bushels per acre. Many rotten; all small.

Monroe County Prize yielded 63 pounds, or at the rate of 462 bushels to the acre. Many rotten.

Woodburn Seedling yielded five pounds. There were 11 hills. This was at the rate of 110 bushels per acre.

New Queen, 22 pieces, yielded 48 pounds, or at the rate of 469.33 bushels to the acre. The tubers were small but there were a great number.

Seedling Rose yielded 71 pounds or at the rate of 520.66 bushels to the acre.

Brownell's Winner (duplicate row) yielded 71 pounds or at the rate of 520.66 bushels to the acre. This last row was planted with seed from Mr. Brownell, while the other row was planted with seed raised here last year, which did not fully mature owing, as stated under the first contest account, to blight and flea beetles.

THE ENTIRE YIELD

was 549 pounds, without making any allowance for decayed tubers, which is at the rate of 367 bushels to the acre. Taking the whole lot, probably over one-fourth were rotten, while the sound potatoes were not over one-half the usual size.

To what extent the premature death of the vines was due to fleas, to excessive rain or to fungoid causes, we were unable to form any opinion.

CHAPTER III.

Another Failure on a Larger Scale, with its Teachings.

THERE is little doubt about it that thoughtful farmers may learn as well by failures as by successes. It is for this reason that we dwell upon the failure of our repeated endeavors to raise over 700 bushels to the acre, or at that rate. We have now to record a failure—the most disastrous, perhaps, of any attempted, though others have since demonstrated that by this very "trench method" the claims made for it are by no means chimerical—the crops having been raised in localities not infested with the flea beetle and blight. The trial to be recorded was made upon a measured half-acre of an impoverished soil.

The yields of from 1,000 to 1,800 bushels of potatoes to the acre (at those rates) raised on specially prepared plots in my experiment grounds of rich, garden soil, have called out various comments from many editors of the press. That we have actually raised such yields need not have been doubted, since the potatoes (of the largest yield and several others nearly as great) were dug and weighed in the presence of several well-known horticulturists or farmers, who were visiting here at the time. But all agree that such yields cannot be raised on large areas except at a cost exceeding their profitable production. It may be that neither 1,000 nor even 700 bushels of potatoes can be profitably raised upon an acre of land. But from our persistent tests with various methods of culture, the question is raised whether we may not at least double our potato crops without doubling the cost of raising them. The two great enemies of immense yields are, first, *drought* and, second, *an insufficient supply of available food.* Now, this NEW METHOD IS TO SUPPLY THE FOOD in abundance, and to so conserve

moisture as to carry the plants through the season without a check in their growth—for potatoes that are checked in their earlier growth *never* yield largely, no matter what the subsequent weather may be.

In order to test this question, whether or not by our method we could raise a large, paying crop on an extended area, a half-acre of very poor land (not capable of yielding 100 bushels to the acre without manure) was given its preparatory fitting. The land was perfectly level and naturally well-drained, consisting of a sandy loam quite impoverished by constant cropping, having received but at the rate of 15 tons of farm manure to the acre in many years, and that in one application four years prior to this trial. An exact half-acre was measured off and plowed eight inches deep, on the 26th of November. The next day it was harrowed, and on the 28th the following fertilizers were spread broadcast, no farm manure whatever being used:

600 pounds of bone-black superphosphate, furnishing 25 per cent. of soluble and available phosphoric acid.

400 pounds of sulphate of potash, furnishing 50 per cent. of sulphate of potash, and 40 per cent. of sulphate of magnesia.

400 pounds of kainit, furnishing 40 per cent. of sulphate of potash, and common salt.

The cost of the above fertilizers was $44 *per acre*, or $22 for the half acre.

On the afternoon of the same day the land was again harrowed, so as to incorporate the fertilizer with the surface soil and prevent its being blown off in case of high winds.

It will be seen that in the above fertilizers there is no ammonia or nitrogen. Either of these would have been washed through the soil ere planting time the next Spring, while it was assumed that the potash and phosphoric acid would be retained. In the Spring it was proposed to sow more of both potash and phosphoric acid, and also a liberal quantity of nitrate of soda.

The object of the trench system of potato raising is two-fold: first, to give a mellow, porous soil for the growing tubers. It is claimed that any considerable pressure upon them must have *some* effect to mar their shape and dwarf their size. The tuber takes no part in the nourishment of the plant, but must itself be nourished *by* the plant and its roots. If, therefore, when and after the tubers begin to form, the plants do not receive an abundance of food, their further growth

must cease, or at least be checked. But without moisture the food in the soil is unavailable, no matter how great soever may be the supply. Hence, therefore, second, the trench system, it is maintained, retains moisture during periods of dry weather, when the soil as ordinarily treated would dry out. The trenches must be plowed (or in small plots, spaded) at least 12 inches wide and six deep. The land should always be plowed in the Fall so that it may be friable and light in the Spring. Choose large tubers, cut them in larger or smaller pieces according to the variety, giving them all the flesh possible, and place them about one foot apart and at least four inches deep in the trenches, which should be about three feet apart. Cover them with an inch or so of soil, throwing it on with as little compaction as possible.

Now, if it is desired to guard against the effects of severe drought, a spread of coarse marsh hay, or something of the kind, after being run through a cutter, may be spread over this soil in the trenches two inches deep. The fertilizers should then be strewn evenly over the hay, and the trenches filled, always as lightly as possible, and ridged up with the soil taken out of them. A rain or so will settle this ridge nearly to a level with the rest. If the land is not liable to be affected by dry weather, the hay mulch, should of course, be omitted. It will be found that the mellow soil of the trench, which readily admits even the lightest rains which fall, and, indeed, heavy dews, will materially help to resist the effects of moderately dry periods. Perhaps, too, the moisture condensed from the air which the porous soil admits, should be taken into the account.

Hilling-up under this system is not only unnecessary but decidedly injurious. The potatoes are planted as deep in the soil as they ever need to be. They receive at once the benefit of rain, which, under the hilling method, is in great part carried off between the hills. The growth of the vines will be found so rapid that few weeds ever start between the plants ; while between the rows, shallow cultivation, (*never deep*) may be given as needed to free the land from weeds and preserve a mellow surface. As with our system of corn culture, I hold that plowing destroys many of the roots, all of which are needed to feed the plants.

THE YIELD OF THE POOR-SOIL HALF-ACRE OF POTATOES.

The lay of the half acre is perfectly level, as just stated, save that

it dishes a little near the middle where it needs draining. Up to date the expense for work and fertilizer was $26.20.

The spring opened so late that it was April 16th before work could be continued, and even then it was questioned whether it would not be wiser to wait awhile and take the chances of planting too late rather than attempt to prepare a soil which was still cold and wet. But the latter course was injudiciously decided upon. Two bags (400 pounds) of Mapes's Potato fertilizer were sown and the land harrowed east and west. The land was then marked north and south, the marks three feet apart. The trenches were made four inches deep (they should have been deeper) with a Syracuse shovel plow, which did not serve the purpose as well as was desired.

THE SEED PIECES.

It was intended to plant only Hodgman Seedling and Green Mountain potatoes, as these in our rich-soil plots had given the greatest yields of any up to that time. Ascertaining at the last moment, however, that but one barrel of seed of the Green Mountain could be procured, it was determined to make the Hodgman seed go as far as possible and to fill out with other kinds. The Hodgman seedling potatoes were found to have been frost-bitten in their passage from New Hampshire. They were cut to one eye generally, though two would have been preferred. The two barrels of seed contained 1,346 potatoes, which, placing one piece every foot in the trench, planted 21 of the 37 trenches of the plot. In the next nine rows, Green Mountain seed was planted. Then followed other kinds, which will be noted further on. The pieces were covered with a hoe with an inch of soil, and upon this soil a further application of potato fertilizer was given at the rate of 800 pounds to the acre.

THE MULCH

consisting of course swamp hay, was run through a cutter and cut in about two-inch lengths. This was strewn over the fertilizer two inches thick from wall to wall of the trench. The soil was then hoed over the mulch, forming ridges two inches above the surface, which soon settled nearly to a level with the adjacent soil after a few rains.

The cost of the coarse meadow hay used was about $3 a ton. It was estimated that one ton would mulch an acre, the trenches being

15 inches wide and three feet apart, measuring from the middle of each. The entire cost of the hay, cutting and distributing it in an economical way when entire accuracy, regardless of cost, is not aimed at, was estimated at $12 per acre.

NITROGEN

was applied in the three forms (mixed together) of blood, nitrate of soda, and sulphate of ammonia, at the rate of 400 pounds to the acre, as soon as most of the sprouts showed above the ground. This was broadcasted, the land receiving immediately afterwards a shallow cultivation.

THE WEATHER

continued cold, with frequent showers. Most of the pieces, however, had sprouted by June 10, except the Hodgman Seedling. It was thus early evident that this portion of the plot—21-37ths of the half acre—would prove a failure. Only here and there could a sprout be seen, while the pieces not sprouted were either quite hard or else were rotting in the ground. Probably not over two-thirds of the seed pieces ever sprouted, and one-third of these were so late in sprouting that no tubers formed—not even small ones. The weather suddenly changed to excessive heat—the hottest of the season—and drought set in. The stems were very large, the foliage so ample that all the land was entirely covered, except that occupied by the Hodgman Seedling. All who saw the plants at this time, with their luxuriant, dark-green leaves, predicted a fine success for the trench method—a prediction, which I grieve to say, was not fulfilled.

The yield is presented below which will scarcely need verification as "doubting Thomases" rarely doubt the results of experiments which turn out agreeably to their views.

To have admitted, however, that we ourselves by this failure were convinced that the principles of this system of potato culture were in fault, would have been premature. While it certainly did fail that season and under the unfavorable conditions as stated, it has succeeded since far beyond the extra cost of its practice, as will be shown directly.

THE YIELD.

Beyond the half acre, a trench was plowed in order to test the natural fertility of the soil as well as the effects of a comparatively

small quantity of fertilizer, both without mulch. Hodgman Seedling from our own seed (not frost-bitten) was planted. The seed *not* fertilized, yielded 163 bushels per acre. The seed fertilized (at the rate of 400 lbs. Mapes's Potato fertilizer per acre), yielded 185 bushels per acre, showing an increase of 24 bushels for the fertilizer.

The State of Maine, the first row of the plot proper (east) yielded at the rate of 240 bushels to the acre, the weight of potatoes dug from this row being 180 pounds. This row, as well as eight others, was 13 feet shorter than the rest, on account of the interference of an apple tree.

Seedling No. 1. There were two rows (Nos. 2 and 3) of this, which together yielded but 195 pounds. This was at the rate of 130.25 bushels to the acre.

The Corliss Matchless (row No. 4 and a part of row No. 5) yielded 150 pounds, or at the rate of 184 bushels to the acre.

The Underwood (116 pieces, row 5) yielded 115 pounds, or at the rate of 238 bushels to the acre.

The Greenleaf (98 pieces, parts of rows 5 and 6) yielded 75 pounds, or at the rate of 184 bushels to the acre.

The Bonanza (78 pieces, row 6) yielded 65 pounds, or at the rate of 200.40 bushels to the acre.

The Montreal (85 pieces, parts of rows 6 and 7) yielded 86 pounds, or at the rate of 243.26 bushels to the acre.

The rest of the row No. 7 was an experiment to ascertain whether anything is gained by rolling the cut surface in plaster and keeping the pieces one week before planting, over planting freshly-cut seed without plaster. The 60 pieces (Green Mountain) plastered and kept a week before planting, yielded 248 tubers (204 marketable) which weighed 59½ pounds. This is at the rate of 238 bushels to the acre. The 90 pieces (Green Mountain) planted as soon as cut without plaster, yielded 493 tubers (347 marketable), which weighed 105 pounds. This is at the rate of 280.58 bushels to the acre—the largest yield of all.

We come now to the nine full rows of Green Mountain. The yield was 27¼ bushels of 60 pounds, which is at the rate of 224.05 to the acre.

Finally, we have 21 rows of the Hodgman Seedling from the frosted seed. The yield was but 24⅓ bushels, which is at the rate of but 86 (85.74) bushels to the acre.

THE COST.

Not counting the cost of harvesting the crop or of the rent of the land, or of the writer's time and labor. we estimated the cost of raising this half acre of potatoes at not less than $60. The entire crop would not that year have sold for more than $40.

CHAPTER IV.

Mr. Terry's views. Small plot trials condemned. Mr. Minch criticized. Ineffectiveness of fertilizers on Mr. Terry's land. Reply. How the yield of acres may be made to equal those of small plots. Mr. Minch's reply to Mr. Terry.

MR. T. B. TERRY, of Hudson, Ohio, is well-known to many of the farmers of the country as a very successful potato grower. It may interest and instruct my readers if I here reproduce a correspondence which occurred between him and the writer regarding large yields in general, and the trench method in particular.

MR. TERRY'S REMARKS.

"Will you allow me to say that I am not quite satisfied with your potato wager as it now stands?

"If the four little words, 'at the rate of' were left out, and the rest read, that you will raise over 700 bushels per acre, on say five acres, this season, then would I clap my hands for joy. Every potato grower in the country would be deeply interested; that is, if he had any progress about him. Should you win such a wager, or come near it, the writer would go to New Jersey both on purpose to see the potatoes and the ground with his own eyes. Very many others would do the same and be benefited. I have long been trying to get just a sight. Once the realization seemed near. I read of a man who was digging some 600 bushels per acre, on two acres. I wrote him immediately and asked if the report was true, and if so, might I come and see some dug? His reply completely cooled off my ardor. He wrote: 'I have two acres of potatoes that will yield

some 600 bushels, not 600 per acre.' This has always been my luck when I have tried to see big yields.

"I do not doubt the yields reported by you; but I do wish the experiments could be on a large scale. Thousands of growers would thank you most heartily. We farmers who live by our crops cannot make much out at thorough experiment work. I wish our experiment stations would experiment with farm crops by the acre instead of little plots of a few rods. Our Ohio director thinks well of this plan, and we hope for something valuable from him in the future.

"Everyone knows there is a great difference in the yield of small plots and the average of whole fields. The yields of Mr. Minch by your trench system show something of this. He had 650 bushels per acre on two acres (would that I could have seen them); 400 per acre on two others, and an average of little over 300 per acre on 22 acres, which I suppose included the first four. Now what we farmers want to know is why did he not average 650 bushels per acre on the 22 acres? Why did two acres produce double the average of the field? Has he learned, so that next time, the season being as favorable, he can bring the whole field up to this high point? I have obtained a yield, on small plots, measured before witnesses, at the rate of 400 to 500 bushels per acre, but have never been able to bring a whole field up to Mr. Minch's average. From my experience I should say that your success was due to heavy manuring, hand culture, absence of hills, rather than to the trenches. If the soil was all mellow and fine, I cannot see what possible advantage a trench 15 inches wide and four deep could have over one four inches wide and the same depth, except that the fertilizer could be put in a broader space, as the first hard rain would in either case, on my soil, settle all ground about alike. As for manure, one can hardly lay too much stress on the value of it. To those liberal doses, year after year, you largely owe your success. I only wish I could use 1,200 pounds of potato fertilizer per acre and make it pay! But the singular thing is that I cannot see one particle of benefit from its use. I have tried the same kind you are using on rows clear through a large field put on in nearly the same way, and at the rate of 1,000 pounds per acre, and never could tell from the growth of the vines or the yield of the tubers where it was put.

"Now, in hand culture, with the hand Planet cultivator you speak

of, I can see that it has an advantage over field culture, where a horse is used. Having the soil mellow and loose so as to supply a 'yielding medium,' which you speak of, is a matter of great importance. A man walking between the rows when the soil is reasonably dry would not disturb the yielding medium, nor even pack the ground where he walked very much.

"When one harrows with a team, and then rolls and plants with a plauter and horses (and it is the same when he marks out and covers with a planter and horses), then harrows some three times to kill weeds, then cultivates six to eight times with horses, he will find his yielding medium considerably injured. I have caused a horse to step on the ground where potato hills were to be, after the seed was planted, and then compared the yield with that of hills in the next row that were not tramped on, and it was largely in favor of the latter. We take great pains to keep the horses in the center between the rows, when harrowing and cultivating. Ridges over the rows or drills enable us to do this when harrowing. The ground is worked but little before planting, partly for this reason. We are also very careful to work the ground only when it is quite dry. A horse will not then pack it so very much worse than a man. In all these ways we study to keep a yielding medium for the potatoes to expand in; but practically we cannot do it as well as you do by hand.

"I shake hands with you on the level culture, or nearly so, that you practice! But do you know that the majority make high hills yet? If they would only stop to think a moment, they would give away their shovel plows, as the writer did years ago. On a field cultivated level, and the surface all mellow, the rain goes right down where it falls, wetting all the soil, and carrying what fertility it has in it right to the growing roots that extend all through between the rows. Where a shovel plow is used before a heavy shower, much of the water runs off in the furrows, carrying its fertility with it. The ground in the hills, instead of being a 'yielding medium' often gets so dry and hard that the yield is injured. Level soil will withstand drought best. In a wet season potatoes will stand hilling better, but on drained land even then hills are an injury. When one takes soil from between the rows to pile up around the hills, he is laying bare, or nearly so, the roots that are alone in the center. This is abusing the plants, and

on drained land I know of no possible benefit to be derived. Better plant about four inches deep and keep the ground nearly level. In practice I have to throw a little dirt in under the plants, with the Planet horse-hoe; but we keep the surface as nearly level as possible. After raising many thousands of bushels in this way we find no more greened or sunburned than when we hilled up high ; in truth I think not so many.

"If farmers would pay close attention to these points another season they will have cause to rejoice, viz. : Plenty of suitable food, as little packing of the soil when working as possible, and level (sensible) culture. Then I would add such tillage as will give the crop the most benefit from the moisture in the soil, or save the most moisture for the crop. After all the main point is the one brought out by you : 'Every farmer does not act upon his knowledge.' It is not how much do we know, but how much use do we make of our knowledge."

REPLY.

We are pleased to receive the above from a farmer who is renowned as a potato grower. It is also to be regretted that we are obliged to answer "at the rate of" instead of "per acre." The reason is this : Offering a wager was thought of only a few months prior to the proposed "contest" and, therefore, too late to give the fall preparation to the land which is deemed essential to great potato yields. Again, it has often been doubted whether we ever did or could raise the large crops, even upon small areas which we have so often reported. Furthermore, it was our desire to use for seed my seedlings Nos. 2, 3 and 4 for this particular trial, and of these we had very limited quantities, no more than enough to plant 100 hills of any, or more than 200 hills in all, which would take about all of the plot that we were prepared to spare. We have never held that proportionately as many potatoes could be raised on an acre of land as upon a selected portion of that acre, for the reason that it is hard to find an acre or more of land of uniform lay, composition and fertility. It is simply held that by employing certain methods the yield of potatoes can be greatly increased as well in field as in plot culture, and profitably increased. We have never known just how much importance to attach to the trenches. Mr. Terry, until of late years, has not been familiar with our experi-

ment work, and, of course knows nothing whatever of the trials to determine how much the trenches, of themselves, increased the yield. In every trial made, the land laid out in trenches, whether with or without fertilizer or manure, has largely outyielded that planted according to the old method of planting in furrows or hills. Every one knows, it is true, the great difference between the yields of small plots and the average of whole fields. This difference is unavoidable, and it must ever be, unless the poorest parts of a field are by manure, drainage, or in some other way rendered as suitable to potato culture as the best parts of the field. We may increase the yield of the poorest parts by special means, such, for example, as by the trench system; but if one portion of a field is liable to suffer more from drought than another, or if other parts are imperfectly drained, we may rarely hope to obtain the best yields from those parts. It is not absurd to say that just as much may be learned from the culture of potatoes on small plots as on acres. The small plot tells us just what the acre needs, and we have only to supply all the wanting conditions to make the latter as productive as the other. It may be doubted if ever any one can discover a method of raising maximum crops of potatoes, or of anything else, unless every need of the crop grown is fully supplied. It may be assumed, however, that the full needs of the potato are not fully understood or, if understood, it has been supposed that it will not pay to supply them. Twelve years ago no one could have made us believe that one day we would raise at the rate of 1,000 bushels per acre on a plot of one-fortieth of an acre. With 60 different kinds of potatoes planted in every way we could think of, and well cared for, the largest yield was less than at the rate of 350 bushels per acre. Not until the trench method was hit upon did we succeed in obtaining these great yields. We do not pretend to understand the effect or action of this system any further than that it seems to conserve moisture and to assist in carrying the plants through droughts which would otherwise check their growth; the depth at which the seed-pieces are placed, the yielding medium by which they are surrounded may all play a part, while the food seems to be placed just where it feeds the plants most effectively.

Mr. Terry asks why Mr. Minch under the trench system did not average 650 bushels per acre on 22 acres instead of on two acres? Our reply would be that he did not or could not supply all the con-

ditions to the 22 acres that existed on the two acres. But he did raise an average of 300 bushels on the 22 acres, and is not this of itself a splendid triumph for this method? The thing for Mr. M. to do now is to endeavor to supply to all of the 22 acres the favorable conditions which exist in the two acres, or to come as near to it as possible.

If the soil of an entire field were all "mellow and fine" alike, we cannot see any clearer than Mr. Terry can what advantages a trench would give. But this is not in practice the case. The plowing or digging of the trench gives additional tilth and pulverization to the extent that in harvesting the crop we can often see the boundary between it and the abutting soil. We are inclined to think that on most soils the first hard rain would not settle all the soil alike, but that the trench soil would still remain somewhat less compact until the vines grew large enough to cover the trench, when they would protect the soil more or less from further compaction.

"To those liberal doses of manure you largely owe your success." If this is the explanation it is of the highest importance to farmers, since the increased crop pays for the manure ten times over, and acres as well as plots may be treated in the same way.

Yes, indeed, we know that the majority of farmers about us in New Jersey and Long Island "make high hills yet." The reason assigned is that the crop is far more easily dug, while the tubers burn less.

"On a field cultivated level and the surface all mellow, the rain goes right down where it falls, wetting all the soil and carrying all the fertility it has right to the growing roots." That is what I have been harping on for twelve years, not only in potato, but in corn culture. It was a part of our system when, on five acres, over 120 bushels of shelled corn were raised *per acre*, the yield having been measured by half a dozen disinterested and well-known persons.

Now it seems to us that the trenches tend to direct the rainfall so that the moisture first reaches the roots where they are the most numerous, and here, too, the fertilizer exists in abundance, while the porosity of the trench soil helps to retain the moisture, and the sheltering leaves retard the surface evaporation.

Finally, Mr. Terry, in the face of your statement that potato fertilizers do not increase your yield, and that you have not much faith in the efficacy of the trench, we beg to make the request that you will plow at least one trench across your potato field (after it is otherwise

fitted) of the depth and width stated; that you will cover the seed-pieces lightly with soil—just barely to conceal them—and then spread evenly in this trench, throughout its length and breadth at the rate of 1,000 or 1,200 pounds per acre, of a high grade, well-balanced potato fertilizer, and that you will publish the results.

MR. MINCH EXPLAINS.

"I was much interested in Mr. Terry's article and your remarks following were read with profit. For the benefit of Mr. Terry I will here explain how I obtained the yield claimed, which can be verified by many having knowledge of the facts.

"In 1885 the two acres named received 1,000 pounds of pure bone dust per acre, 500 pounds of kainit, 20 two-horse loads of well-rotted compost of stable manure, and 800 pounds of phosphate to each acre. In 1886 the same received 20 two-horse loads of stable manure compost and 1,000 pounds each of fine bone dust and kainit. In 1887 there was applied the same quantity of compost, bone and kainit, making in three years, to each acre, 60 loads of rich stable compost (equal at least to 120 loads of ordinary raw manure,) 3,000 pounds of bone, 2,500 of kainit, and 800 of phosphate. This, some would say was an enormous waste of fertilizers, but I wanted to test the matter of economy of the use of so large a dressing. The season of 1887 was, in South Jersey, a remarkable one for moisture and freedom from hot sun and sun-scald. The yield was as I have given it. The soil is a friable clay loam, of excellent drainage, and a very favorable one for the experiment. This year I propose again to use on each acre 20 two-horse loads of stable compost and 1,000 pounds each of the fine bone and kainit.

"The 22 acres alluded to had no manure applied to them like the two acres named, or the yield would have been much greater. Mr. Terry is in error in supposing that the average of the 22 acres of 312 bushels per acre included the first mentioned plot of two acres. The crop of each plot was given separately. The large yield obtained was secured by deep, close planting—not more than 10 inches apart in the row, and the rows three feet apart. This gives, if there be a perfect stand, 16,940 plants per acre, and should each plant yield only 2½ pounds per hill it would aggregate a yield of over 700

bushels per acre. Unless the potatoes are closely planted, where manure is used so excessively the growth will run largely to vine, and the yield will be comparatively trifling." [This depends upon the size of the vines, does it not? The Early Ohio, for instance, might well be planted 10 inches apart, but we should hesitate about planting such varieties as the Blush, White Elephant, etc., less than a foot or 14 inches apart.—E. S. C.] "Deep planting in the soil described allows double setting of the tubers; often triple sets are found—one at the bottom of the trench, one at the top, and one between these. The largest yields can never be obtained where there is neglect of any of the essentials of success in the culture. I cultivate well before the plants appear, and as little as possible afterward. Too much after culture is a serious injury to the potato, and will largely reduce the product. My purpose has been to test the economic part of the problem, and so far the heavier use of fertilizers has been best. I find that fewer acres and more manure, accompanied with a careful study of the requirements of successful culture, afford better results than the cultivation of a large area with a smaller average yield.

"Mr. Carman is doing a good work and will come out successful in the potato contest. Should this coming season be favorable, I will invite Mr. Terry to see a few potatoes. Should there be failure from any cause, I will cheerfully chronicle my defeat."

CHAPTER V.

Some Heavy Yields by the Trench Method.

IN 1888 an offer (through the paper I then controlled) of something over $1,000 (in sums of $150 and less) was made to the wives of American farmers for the largest yields of potatoes to be produced on not less than one-fortieth of an acre. The enterprise was known as the WOMEN'S NATIONAL POTATO CONTEST, and the interest shown from the outset until the close was certainly worthy of the name. There were over one thousand entries. Nearly all of the prizes for the heaviest yields were awarded to those who adopted the trench system, and the crops, as figured per acre, ranged from 1,062 bushels (the highest) to something over 300 bushels. The first prize (one-twentieth of an acre) was awarded to Mrs. Selinda E. Jones, of Chautauqua county, N. Y., and the variety of potato was the White Elephant or Late Beauty of Hebron—they are the same. The yield was 53 1/12 bushels—2,735 pounds of marketable and 450 pounds of unmarketable potatoes, or at the rate of 1,061⅔ bushels to the acre.

The second prize was awarded to Mrs. Eliza Day, of Johnson county, Wyoming. The plot was one-twentieth of an acre—variety Early Vermont, yield 48 bushels 33 pounds of marketable, and two bushels 14½ pounds of unmarketable, or at the rate of 1,015⅘ bushels to the acre.

The third prize was awarded to Miss Mary Rusk, of Madison county, Illinois. The plot was one-fortieth of an acre, or thirty-three feet square; the variety was Chicago Market, and the total yield was 24 bushels and 16 pounds, or at the rate of 970.66 bushels to the acre.

The fourth prize was awarded Miss Emma Hissam, of Steele county, Minnesota. The area was one-twentieth of an acre, variety Late Rose; yield 46 bushels, one peck, or at the rate of 925 bushels to the acre.

The fifth prize was awarded to Mrs. M. T. Covell, of Erie county, Ohio. The area was one-fortieth of an acre; varieties Green Mountain and Rural Blush; the yield was 1,380 pounds, or at the rate of 920 bushels to the acre.

The sixth prize was won by Mrs. Agnes C. Cameron, of Texas county, Missouri. The area was one-fortieth of an acre; the varieties Rural Blush and Beauty of Hebron; the yield 1,282, of which 1,260 pounds were marketable, or, at the rate of 854⅔ bushels to the acre.

The seventh prize, and the last we need here record, was awarded to Mrs. Mary E. Warren, of Fairfield county, Connecticut. The area was one-fortieth of an acre, the variety White Flower; the yield (total) was 1,215 pounds, or twenty bushels and one peck, being at the rate of 810 bushels per acre.

THE TRENCH SYSTEM FINALLY GIVES 738 BUSHELS TO THE ACRE.

Contemporaneously with the above recorded Women's Contest, though announced afterwards, another was being conducted by the owners of the *American Agriculturist*, supported by a number of enterprising firms. The prescribed area was not less than an acre or, if less than an acre, no allowance was to be made for the shortage. The first prize, $1,100, was awarded to Mr. C. B. Coy, of Presque Island, Maine. The crop was raised in strict accordance with the trench system, as will appear by the following note in reply to my inquiry:

January 10, 1890.

DEAR SIR: I was induced to use the trench system in planting my prize acre by seeing a report of some very large yields raised by that method, in the Bowker Fertilizer company's hand-book. The large yields I refer to were raised by you on the Rural Experiment Grounds. I shall plant all my potatoes that way another year. I think the system a grand success.

Presque Isle, Maine. CHAS. B. COY.

The yield was 738 bushels on the acre, or rather it was a fraction

less than an acre, the exact deficit having escaped my memory. The particulars, in so far as they need be stated, were as follows :

Eleven hundred pounds of the Stockbridge potato manure were scattered along the bottom of the trenches, after they had been laid off for the seed, and were well mixed with the earth in and about the trenches by hand with the hoe before planting. The balance (900 pounds) was applied June 12th at the time of the first hoeing, etc. The land was laid off in trenches two feet nine inches apart. The seed was dropped 12 inches apart. It was covered by the hoe to a depth of two or three inches. Only such tubers were selected for seed as had strong, green sprouts at the time of planting.

The seed was taken from the cellar about six weeks before planting and spread thinly on the floor of a dry and warm room in the house.

There is nothing else in the cultivation of this magnificent crop that needs to be noted except that the acre was plowed during the preceding summer (August); again plowed (cross-plowed) the next spring and thoroughly harrowed two weeks after. The variety raised was Dakota Red.

CHAPTER VI.

Conservation of Moisture—Importance of Rainfall—Ineffectiveness of American Experiment Station Work.

ABOUT the time that the proposed Women's National Potato Contest was being discussed, Dr. Lawes, the world-renowned experimenter of Rothamsted, England, favored me with the following brief but suggestive letter. As another and more lengthy communication appears from this grand man—to whom the entire world is under a load of indebtedness, which it but imperfectly recognizes at present, but which it surely will more adequately recognize in the future—I may be pardoned for saying that it was through my repeated solicitations that he was first induced to write for the American farm press, and that it was to his work and influence more than to all other causes that I was induced to commence experiment work—experiment stations were then virtually unknown in America—the results, in so far as potatoes are concerned, being for the most part placed before the reader in this book. I am by no means alone in assuming that it was in a great measure owing to the publicity thus given to farm experimentation in this country that, let my own participation be reckoned, as it should be, of comparative insignificance, governmental action in favor of State stations was precipitated. Up to this time, however, these experiment stations have been of trifling service to the people they are intended to help, and, it may well be feared, they never will be of service at all proportionate to their cost until their fundamental weakness is recognized and repaired. The director is, as a rule, chosen through political influence, with little regard to his fitness for the position. His assistants are appointed not because they are capable men, but because they are available men

who, out of employment, are glad to accept of salaries which capable men could not afford to accept. Their tenure of office is, from the nature of the case, uncertain, and it is soon ascertained that the reward of devoted services is, if not gobbled up by their superior, at least unduly shared with him. The few exceptions to this disheartening state of things, made by bright, ambitious young fellows, soon lead to better offers from agricultural colleges or other (for the time) better conducted stations, and the promising young fellows quit the work which is but fairly begun, to plunge into work of a necessarily different character owing to the needs of a different locality, soil and climate. Necessarily, therefore, while such a state of things exists, there is little hope that the station employees of this country may ever work out those or cognate problems which, at Rothamsted during the past forty-five years, have received the patient, unremitting study and toil of trained hands, enthusiastic hearts and competent heads.

IMPORTANCE OF WATER TO THE POTATO CROP.

"If you want to grow large crops of potatoes you must be liberal in your supply of water as well as of food. The following table will give you some idea of the importance of rainfall even when the potatoes have abundance of food. We grow potatoes continually upon the same land, using the same manures, viz: 300 pounds of sulphate of potash, soda, magnesia, superphosphate, with, in one experiment, 400 pounds of sulphate of ammonia, and in another, 550 pounds of nitrate of soda. The potash and phosphate are in excess of the requirements of the largest crop grown, so they are accumulating in the soil. The nitrogen is also largely in excess of what the crop takes up, but this does not accumulate.

Rainfall in inches May to October, 5 mos.	*Bushels per acre.*
1881, 13½.	482
1882, 12⅓.	387
1883, 13.	401
1884, 9.	222

"In 1881 the rainfall was better distributed over the season than it was in 1883. Of course, I do not advocate the use of irrigation unless for the purpose of experiment, but merely wish to point out how im-

portant an abundant supply of rain is. The rainfall last year was fairly abundant for all other crops, but not for the potato.

"J. B. LAWES."

Sir J. B. Lawes's letter, received at a time when hundreds were preparing to try the new method, seemed to emphasize the importance of any kind of culture which gave promise of a conservation of moisture.

THE TRENCH METHOD OF CONSERVING MOISTURE.

The potato plant, before the tubers begin to form, never suffers from drought any more than do young corn plants; but when the tubers are forming, their supply of moisture *must* be unfailing, or a check in their growth *must* follow—and a *check* means a small crop, or, if growth should be resumed, a prongy crop. We would ask our readers to compare the weight of the tubers produced by a given plant and the weight of the haulm (stems and leaves) of that plant. The tubers must grow and mature during a few weeks. They are nearly three-quarters water, and the leaves and stems and fibrous roots, which together generally weigh less than the potatoes, are taxed to their utmost to supply this water and the food it holds. It does not matter in the least how rich the soil is, without moisture the food is unavailable. We have already explained how the "trench" system is supposed to conserve moisture. We wish now to *urge* our readers also to try, at least in one trench, the effects of mulching. In our early tests, given in detail further on, the *mulched* trenches increased the yield over the unmulched trenches 88 bushels per acre, both fertilized with essentially the same quantity and kind of fertilizers. Two inches of cut straw, coarse hay, or wheat, rye, barley or oat chaff, will serve the purpose, and if by its use, the yield can be increased during dry seasons our farmers may well afford to apply it. The drawback is that it is impossible to predict whether the season will be wet or dry.

The trench system will be found not to require the additional labor and expense that many suppose. But in the other case, if the increased yield will more than repay the cost, why not adopt it? Let every one of our farmer or gardener readers bury his incredulity or prejudices for the once, and give the method a careful, *exact* trial.

A common plow may be used to form the trenches by plowing both ways, forming an open or dead furrow—or a shovel or listing plow may be used. Let the bottom of the trenches be 10 inches wide *at least.* This bottom should be mellowed, and the seed potatoes placed one foot apart. Cover them with two inches or more of soil. Then apply the mulch, scattering it *evenly* over the surface-soil of the trench, and then sow the *complete potato fertilizer* at the rate of 500 pounds (or more) to the acre. Finally, fill the trench as *lightly* as possible with the return soil, and give level cultivation.

OBJECTIONS TO THE TRENCH.

Several friends, as did Mr. Terry, have asked this question: "If I thoroughly prepare my field so that all of it is the same as the trench, what would be the use of plowing a trench?" There would be no use whatever in so far as the mellowness of the soil could increase the crop. The trench, however, would still enable the farmer to place the fertilizer just where it is most needed for that crop and it would further enable him to plant deeper, a consideration, as we believe, of the first importance. In practice, however, it may be repeated, we have never seen a field so well prepared that plowing a trench and refilling it would not still further mellow the soil.

Again, the objection to the trench and to level culture has been made that more tubers become exposed to the air, becoming green and worthless. Such an objection will never be made by those who have given it a thorough trial. Having plenty of soil in which to form without being crowded, they rarely grow above the soil. Another objection is that it costs more to harvest trench than hill potatoes, an objection that is valid enough if the increased yield from the trenches is not enough to pay for the extra labor. It is not the work that a farmer puts on his crops, neither is it the cost of the manure that must first be taken into account. The question is, "*will it pay?*"

Treading on the seed-piece after it has been dropped into the hill or drill is approved of by many thorough-going farmers because it insures a closer contact of the piece with the soil. But this is quite at variance with our ideas of trench culture. If the design were to smash the piece of potato or to injure the eyes, it would be more or less effective, no doubt. If the roots grew out of the potato there

might be some sense in it. But the soil has nothing to do with the starting of the roots any further than it provides moisture. The roots grow out of the stem which is for a time supported by the seed potato itself. · The sprout, shoot or stem makes its way through the soil, and the contact of the mellowest soil is sufficiently close. To keep it mellow—not to compact it—is the problem, and this problem is solved more nearly, in our opinion, by the trench than by any other method of potato culture known to-day.

CHAPTER VII.

Experiments with Different Fertilizers on Potatoes.

FIRST SEASON.

THESE tests with different fertilizers, and with various combinations of them, seem to the writer to be as instructive as any similar experiments can be that are not repeated from year to year. Many experiments of this kind are altogether contradictory, for the reason, probably, that the soil in which they are made is not so far impoverished that they will show what food is really needed. Many farmers who have tried plain superphosphates alone, raw bone alone, or potash alone, or any two, will see from these tests that they ought not condemn so-called chemical fertilizers because any one, or even any two, should fail to give a marked increase of crop. If a soil needs all kinds of plant food and is supplied with but one, no matter how large the quantity may be, the crops will not be materially benefited. Thus it will be seen that in these tests, potash alone did no good; dissolved burnt bone, which furnishes phosphoric acid only, did no good. Nitrogen increased the growth of the vines, which, for want of potash and phosphoric acid in the soil, gave, it is assumed, no increase of tubers. But the complete fertilizers--those which furnish all three—gave an increase of crop in every case.

Study this question, farmers. It will pay you to do so. If you don't know what your land needs, use COMPLETE fertilizers, with a fair per cent. of the three essential constituents, until you find out. You CAN find out by making just such experiments as those which are given. When we hear farmers say that they have tried kainit, or superphosphate, or sulphate or muriate of potash, without the slightest effect, we earnestly desire to explain the thing to them as we ourselves un-

derstand it. Let it be borne in mind that five tons, or a greater or less amount, of potash or plain superphosphate of lime, or both, might be spread upon an acre without ANY result. But let us even the next season, or possibly ten years afterwards, supply nitrate of soda or salts of ammonia plentifully, and the farmer would no longer say that fertilizers were worthless upon his soil. Plants, like human creatures, need a complete food, and if the soil does not supply it, we must feed the soil with the deficient element. If the soil from exhaustion needs every element, we must supply a "complete" food, complete in the quantity as well as in the number of food components.

Let us further consider that farm manure, aside from its mechanical effects, is precisely the same as the so-called concentrated fertilizers, except that it is less soluble. That is to say, if we could burn farm manure, and still preserve all of its nitrogen, the ashes would show just exactly what we may furnish to the land in chemical fertilizers. It is very plain, however, that the mechanical effects of bulky manure can never be supplied by fertilizers.

We are not, just now, advocating the use of fertilizers at all—neither are we discussing the question as to whether, at their present price, we can AFFORD to use them. We merely wish to show that they *do* furnish the elements of food to plants the same as stable or farm manure or composts of leaves, muck, straw or any other substance furnishes them, and that we have but to supply the elements which our soil needs to render it fertile.

As shown in the tests given in detail as we proceed, there is in the main no positive contradiction in the results. All the plots tell, if averages be considered, about the same story, and that is, that this particular worn-out loam needs COMPLETE fertilizer—that is, phosphoric acid, potash and nitrogen. Nitrogen alone, while it gave greater growth of tops of a deeper green color than the others, could not sustain the plants to a full maturity. The tops therefore died, and the yield was poor. The disparities between individual plots are such as may be looked for in any system of experimentation that is not carried on for years in succession in the same way and upon the same soil.

Plot 27, which gives by far the greatest yield, received less fertilizer than either plots 12 or 17. It may reasonably be concluded, therefore, that this is owing to the two inches of short-cut timothy

hay which was spread as a mulch. The pieces were covered, as were all the others, with two inches of soil. Upon this the hay was evenly spread across the trench, and upon the hay 500 pounds (per acre) of potato fertilizer and 50 pounds of kainit were strewn. The early part of the season was so dry that it was thought that all of the potatoes received a check. It was then, no doubt, that the mulch of hay performed its best service.

These experiments were designed to test the effects of the various concentrated constituents of which commercial fertilizers are composed, separately and in various combinations. The soil of the plots selected was, as stated, a worn out sandy loam, level and naturally well drained. There was no air stirring to interfere with the even distribution of the fertilizers ; the soil was mellow and moist without being wet, and with ample assistance the entire work of sowing the fertilizers, planting and finishing the plots, was accomplished between 7 in the morning and sunset of April 14th.

The seed had been cut several days previously, the White Star having been selected as, by its season of maturing, keeping qualities and vigor, well suited to such tests. Potatoes of nearly the same size were cut in halves lengthwise, the seed end of each having been cut off and rejected. The seed conditions were made still more equal by using the same weight of seed pieces to each plot. Trenches had been dug several days previously, two spades wide and six inches deep—the trenches *six* feet apart so that the roots of one trench should not reach and feed upon the fertilizer of the adjacent trenches. Later, two inches of soil were raked into the trenches, and upon this the pieces (cut surface down) were placed one foot apart, April 14th, as stated above. Two inches of the soil were raked over them and the different fertilizers applied as shown in the table further on.

As regards the yield per acre, the two extremes may be given—first, the mulched plot (No. 27) which received fertilizer and kainit ; and, second, the average yield of the plots *not* fertilized. It must be borne in mind that the trenches were six feet apart. Very likely they would have yielded nearly as well had they been three feet apart, the distance usually allowed. At six feet apart the yield of the mulched plot (No. 27) was at the rate of 172.33 bushels to the acre, or 344.66, were the yield to be estimated from trenches three feet apart, which, for ready comparison with the later trials, has been preferred.

The average yield of the plots *not* fertilized, at six feet apart, was at the rate of 69.66 bushels to the acre—or had the trenches been three feet apart, double that amount, or 139.32 bushels to the acre. If we take the average yield of all the plots which did not receive "complete" fertilizers, we find it to be at six feet apart at the rate of 79.75 bushels to the acre—or at three feet apart 159.50 to the acre. The *special* fertilizer therefore *increased* the yield, *only 10 bushels to the acre*, if we reckon at six feet apart ; and 20 bushels, if at three feet apart, as compared with the *natural soil;* while the *complete* fertilizer and hay mulch increased the yield, over the natural soil, 102.69 bushels to the acre, if planted six feet apart, and 205.38 bushels to the acre, if planted three feet apart. With the complete fertilizer (potash, nitrogen and phosphoric acid) and *without* the hay mulch (plot No. 17), the yield was increased over the natural soil or unfertilized plots, 58.67 bushels to the acre at six feet, and at three feet 117.34 bushels to the acre. With the complete fertilizer of plot No. 12 the yield was increased 38.50 bushels if planted six feet apart, and 77 bushels if three feet apart.

POTATO FERTILIZER EXPERIMENTS.

Showing the comparative yield per acre, the fertilizers used, and the relative size of vines.

FERTILIZER USED.	*Fertilizer. Pounds per acre.*	*Vine Growth June 16.*	*Bus. of potatoes to acre.*
No. 1. Nitrate of soda....................	200	9	124.66
No. 2. Sulphate of ammonia..............	120	8.50	124.66
No. 3. Dissolved bone-black	400	5	122.83
No. 4. No fertilizer		5	100.83
No. 5. Sulphate of potash (50 per cent.) ..	300	5.50	154.00
No. 6. Plaster	400	5.50	141.16

FERTILIZER USED.	*Fertilizer. Pounds per acre.*	*Vine Growth June 16.*	*Bus. of Potatoes to acre.*
No. 7. Lime	2,000	6	161.83
No. 8. Nitrate of soda	200		
Dissolved bone-black	400	9	170.50
No. 9 No fertilizer		5	135.66
No. 10. Nitrate of soda	200		
Sulphate of potash	300	9	232.83
No. 11. Dissolved bone-black	400		
Sulphate of potash	300	5.50	174.16
No. 12. Nitrate of soda	200		
Dissolved bone-black	400	10	216.33
Sulphate of potash	300		
No. 13. Fine ground bone	1,000	6.50	157.66
(No plots between Nos. 13 and 16)			
No. 16. No fertilizer		5	172.33
No. 17. Mapes potato manure	800	10	256.66
No. 18. Farm manure, two years old	20,000	8	221.83
No. 19. No fertilizer		5	141.16
No. 20. Sifted coal-ashes	40 bus.	5	141.16
No. 21. Kainit	880 lbs.	5.50	159.50
No. 22. Kainit	1,760	5.50	188.83
No. 23. No fertilizer		5.50	154.00

FERTILIZER USED.	Fertilizer. Pounds per acre.	Vine Growth, June 16.	Bus. of potatoes to acre.
No. 24. Unleached wood-ashes from burnt brush	41¼ bus.	5.50	165.00
No. 25. Hen manure	55 bus.	9	176.00
No. 26. No fertilizer		5	154.00
No. 27. Mapes potato manure Kainit Hay mulch	500 lbs. 50 —	8	344.66

It must be explained that the "vine growth" as exhibited in the second column of the preceding table is intended to show the size and vigor of the plants as they appeared at the time noted, June 16. Such observations have been carefully made in most of these potato experiments, the aim being to see in how far the yield of tubers accords with the growth of vine. Ten is the number to denote the maximum of vigor, lower numbers indicating less vigor and size. It has been found a very trustworthy way of *guessing* at the yield ; that is to say, the yield of tubers is generally proportionate to the development of the vines.*

SECOND YEAR'S TRIAL ON DIFFERENT LAND WITH THE SAME FERTILIZERS AND FERTILIZER CONSTITUENTS.

Here we have a soil that will not "grow beans," or even a good crop of weeds without manure. Though cropped year after year, this part of the field has received neither fertilizers nor manure for many years. It was, therefore, very hungry, and ready to show its appreciation of a full meal, which rich soils never do. What did the soil need, was the question again asked ? Was it bone, or potash, or ammonia—one, two or three ? Would ashes or hen manure or farm

*The potato fertilizer used (Mapes) had the following guaranteed analysis:

1.46 Nitrate soda.	3.90 Soluble phosphoric acid.	Potash 7.32.
.85 Ammonia.	4.32 Reverted " "	
1.60 Organic.	2.54 Insoluble " "	
3.91—Total.	10.76—Total.	

manure or plaster give a good crop? Would fertilizer give a larger crop than manure? Would ground fish yield a good crop? Would nitrogen alone in excess help the crop? Would a large quantity of nitrogen alone produce a paying crop? Would phosphoric acid or potash, or the two combined, prove sufficient for a profitable crop? Could a well balanced "complete" manure for potatoes be made from dissolved rock, nitrate of soda and muriate of potash? How would the same compare with the highest priced "complete" potato manure offered by dealers? All these questions we hoped to answer by this series of experiments.

The land was plowed April 10. The work of planting was begun at eight o'clock, April 14, and finished at 5.30, three men being employed. The "Calico" potato (a seedling of my own) an early variety, was the "seed" planted. In the previous year's trial it was the White Star, as noted—an intermediate kind. There was, as in the previous trial, scarcely a breath of air moving to interfere with the even distribution of the fertilizers. The season was favorable to a maximum yield from first to last.

In the following, as in the preceding tables, the heavy lines show the rate of yield per acre and are drawn to a scale—one-eighth of an inch representing 10 bushels—one inch equal to 80 bushels. All the potatoes were weighed, regardless of size, and 60 pounds rated as a bushel.

Plots.	*Fertilizer.*	*Pounds applied per acre.*	*Vine Growth May 27, 10 maximum.*	*Yield bushels per acre.*
No. 1.	Nitrate of soda	200	3	141
No. 1½.	Natural soil	——	2	88
No. 2.	Sulphate of ammonia	120	4	132
No. 3.	Dissolved bone-black	400	4	103
No. 4.	Natural soil	——	2	97
No. 5.	Sulphate of potash	300	2	95

Plots.	Fertilizer.	Pounds applied per acre.	Vine Growth May 27, 10 maximum.	Yield bushels per acre
No. 6.	Plaster	400	1	90
No. 7.	Natural soil	——	2	68
No. 8.	Nitrate of soda	200	2	110
	Dissolved bone-black	400		
No. 9.	Farm manure, two years old	20,000	4	147
No. 10.	Nitrate of soda	200	2	90
	Sulphate of potash	300		
No. 11.	Dissolved bone-black	400	2	81
	Sulphate of potash	300		
No. 12.	Nitrate of soda	200	3	84
	Dissolved bone-black	400		
	Sulphate of potash	300		
	This plot was affected by the roots of a tree.			
No. 13.	Raw bone	1,000	4	77
No. 14.	Farm manure, two years old	20,000	4	100
No, 15.	Natural soil	——	1	59
No. 16.	Hen manure	1,440	4	81
No. 17.	Mapes' potato manure	800	9	176
No. 18.	Farm manure, two years old	20,000	6	169
No. 19.	Mapes' potato manure	1,200	9	273
No. 20.	Acid phosphate	700	6	156
	Nitrate of soda	200		
	Muriate of potash	120		

Plots.	*Fertilizer.*	*Pounds applied per acre.*	*Vine Growth May 27, 10 maximum.*	*Yield bushels per acre.*
No. 21.	Acid phosphate	700	3	110
No. 22.	Nitrate of soda Muriate of potash	210 120	3	139
No. 23.	Ground fish	400	7	124
No. 24.	Mapes' potato manure The seed pieces mulched with old straw, Rural trench mulch system.	1,200	8	323
No. 25.	Natural soil	——	2	59
No. 26.	Hen manure	2,880	7	147
No. 27.	Blood Nitrate of soda Sulphate of ammonia	1,100	8	183
No. 28.	Mapes' potato manure, 1,200 lbs., with the following nitrogen mixture added: Blood Nitrate of soda Sulphate of ammonia Mulch was used same as 24.	600	10	235
No. 29.	Same as 28, except that a mulch of old straw was spread over seed pieces		8	224

COMPARATIVE AVERAGE YIELDS.

Average yield of the trenches with neither manure nor fertilizer:

74 bushels per acre.

Average yield of the trenches with incomplete fertilizers:

112 bushels per acre.

Average yield of the trenches with hen manure:

114 bushels per acre

Average yield of the trenches with ground fish:

124 bushels per acre.

Average yield of the trenches with farm manure:

139 bushels per acre.

Average yield of the trenches with complete potato fertilizer:

221 bushels per acre.

The largest yield was given by trench No. 24, which received the complete fertilizer and a mulch of old straw which had been exposed to the weather during the entire winter. This was spread two inches deep in the trench directly on the potato pieces after they had been covered with an inch of soil and the fertilizer used for that trench. The yield was at the rate of 323 bushels to the acre, or 50 bushels more than where the same quantity of the same fertilizer was used without mulch in trench No. 18. When, however, the trenches Nos. 28 and No. 29 are compared, it appears that the mulch did not increase the yield. While in trench No. 27 an excessive dressing of nitrogen alone (in three forms) seems to have raised the yield 109 bushels per acre over the natural soil yield, it seems to have lessened the yield when added to the complete fertilizer 44 bushels, as compared with trench 19. While, therefore, an excessive application of nitrogenous fertilizers alone may be supposed to increase the yield by acting upon the latent potash and phosphate of the soil, an over-dose in addition to an ample supply of complete fertilizer seems to be injurious.

While it is plain that this series of experiments, as do the first series, show that a complete fertilizer alone will produce a maximum crop in this soil, the action of partial fertilizers is in some cases contradictory and in many cases unsatisfactory.

In row No. 1 nitrate of soda gives 141 bushels to the acre, and yet in No. 8 the same quantity (200 pounds per acre) of nitrate of soda, together with 400 pounds of dissolved bone-black, gives only 110 bushels; 31 bushels less than pure nitrate of soda alone. Again, in No. 10 nitrate of soda and sulphate of potash give only 90 bushels, while in plot No. 5 sulphate of potash alone gives at the rate of 95 bushels. Similar contradictory results seem to rule in the majority of experiments reported of this class of fertilizers. Their action is so largely an indirect one on the other ingredients already in the soil, and in so many ways they act and re-act on the soil and themselves that it seems to be impossible to trace their plant-feeding powers. The results from their use in an experiment in 1884 were more contradictory than during the past year. Nitrate of soda gave promise in the vine growth of a good crop, equal to that of the best complete manure, instead of which it failed to hold out through the season and yielded little more than the natural soil. The results from sulphate of ammonia were little if any better than from nitrate of soda—fair promises and poor results.

Complete manures, especially the complete potato manure, prove themselves to have adequate feeding resources of their own. They seem to feed the crop from their own resources, not only producing healthy vine growth, but bringing large yields.

THIRD YEAR'S TRIAL ON DIFFERENT LAND WITH ESSENTIALLY THE SAME FERTILIZERS AND FERTILIZER CONSTITUENTS.

As to the preparation of the plots, it is hardly necessary to repeat what has been said on preceding pages. The seed, Rural Blush, a late variety, was cut the day previous to planting. Potatoes of nearly the same size were cut in halves lengthwise, the seed ends of which had been cut off and rejected. The seed conditions, as before, were made still more equal by using the same weight of seed pieces to each plot. Trenches had been dug several days previously, fifteen inches wide and six inches deep, the trenches three feet apart. Later, two inches of soil were raked into the trenches, and upon this the pieces (cut surface down) were placed one foot apart. Two inches of soil were raked over them, and the fertilizer applied as described. The season, for this land, was considered favorable. The work of planting and fertilizing was completed by three men in one day.

		Pounds fertilizer per acre.	*Yield bushels per acre.*
1.	Nitrate soda	200	235
1½.	No manure	00	256
2.	Sulphate of ammonia	120	301
3.	Dissolved bone-black	400	266
4.	No manure	00	242
5.	Sulphate potash	300	272
6.	Plaster	400	225
7.	No manure	00	260
8.	Nitrate soda	200	354
	Dissolved bone-black	400	
9.	New York manure	10 tons	433
10.	Nitrate soda	200 lbs.	376
	Sulphate potash	300 "	
11.	Dissolved bone-black	400 "	245
	Sulphate potash	300 "	
12.	Nitrate soda	200 "	348
	Dissolved bone-black	400 "	
	Sulphate potash	300 "	
13.	Raw-bone	1,000 "	290
14.	N. Y. manure forked in the bottom of the trench and the seed-pieces placed on top	10 tons	280
15	No manure	00 lbs.	272
16.	Hen manure	2,640 "	323
17.	Mapes's potato manure	800 "	332
18.	N. Y. manure spread on the top of the covered seed-pieces. (Mulch system)	10 tons	348
19.	Mapes's potato manure (ammonia 4.50; phosphoric acid, 8.00; potash, 6.00)	1,200 lbs.	511
20.	Acid (S. C. rock) phosphate	700 "	381
	Nitrate soda	200 "	
	Muriate potash	120 "	
21.	Acid phosphate	700 "	229

		Pounds fertilizer per acre.	*Yield bushels per acre.*
22.	Nitrate soda..................	200 "	323
	Muriate potash	120 "	
24.	Nitrogen mixture, viz: equal parts sulphate of ammonia, nitrate soda and dried blood, 200 pounds of each, per acre, was spread on top the seed-pieces after they had been lightly covered with soil, and 10 tons N. Y. stable manure spread on top of this for a mulch.....................		476
25.	No manure		269
26.	Floats (finest S. C. rock)	1,000 lbs.	289
27.	Peruvian guano	400 "	264
28.	Hen manure	5,280 "	363
29.	No manure		246

AVERAGES.

No manure plots average.........................	253
Single chemical constituents	263
Two " "	324
Three " "	364
Potato fertilizer..................................	421
Stable manure	354
Hen manure	343
Fish	323

THE PROMISE OF YIELD AS INDICATED BY THE VINES JUNE 27TH.

As in preceding years, we rated the growth and general appearance of the vines, with the view to ascertaining in what degree the yield of potatoes would correspond with the promise thus indicated. Ten (10) is the highest *possible* rating.

Plot 1	Rated 2	Plot 15	Rated 3
" 1½	" 2	" 16	" 5
" 2	" 3	" 17	" 6
" 3	" 3	" 18	" 5
" 4	" 2	" 19	" 9
" 5	" 3	" 20	" 8
" 6	" 2	" 21	" 3
" 7	" 2	" 22	" 3
" 8	" 4	" 23	" 3
" 9	" 5	" 24	" 8
" 10	" 4	" 25	" 2
" 11	" 3	" 26	" 3
" 12	" 5	" 27	" 3
" 13	" 4	" 28	" 5
" 14	" 4	" 29	" 3

One often hears of immense tops, and yet a very small yield. This has occurred in my experience, though in more fertile soil; first, when large quantities of unleached ashes were used, and, second, when farm manure alone was used, plowed under the preceding fall. With well balanced chemical fertilizers alone it has never occurred; indeed we believe, though we do not know, that with well balanced complete fertilizers a heavy growth of tops is an almost unfailing indication of a large crop of tubers, even though as high as two tons of fertilizer to the acre be used.

THE LAND.

The land of the plots was, as is plainly shown by the good yields without manure, much more fertile than that of the plots experimented with in previous years. The change was made because there seemed no longer any reason for continuing the poorer land trials, since the result of two seasons of trial proved beyond a doubt that the soil needed all kinds of plant food, and that a decidedly increased yield could not be secured without them. They were therefore given up in favor of richer land, though of the same character, a loam inclining a trifle to sand rather than to clay.

It will be seen that the results are variable, though complete ferti-

lizers still give largely increased yields over special constituents, and the valuable lesson taught in this case, as in the previous trials, is that for potatoes, it pays well on this land to use them in preference to partial fertilizers or even to hen, fish or stable manure. The manure was from New York stables, well decomposed, and of apparently excellent quality. The Peruvian guano contained an undue weight of stones and we do not regard the trial as a fair one. The variableness of the yields is probably due in a measure to two causes, viz: (1) potatoes were raised upon the same land the year before, fertilized in the drill, and (2) corn was raised two years before, manured in the hill.

A LETTER FROM SIR J. B. LAWES RESPECTING THE EFFECTS OF DIFFERENT FERTILIZERS.

Having presented the results of our own experiments touching this very important question in regard to the effects of fertilizers (complete and special or partial) on the growth of potatoes, I may conclude the subject with the following valuable communication which I have received from Sir J. B. Lawes, of Rothamsted, England:

"Although I consider that the use of complete artificial manures involves too great a cost for their employment in the growth of ordinary farm crops, perhaps an exception may be made in regard to potatoes, a crop which requires a large supply of both potash and nitrogen.

"At Rothamsted, we have grown nine crops of potatoes in succession upon land which for 16 years previously had received no yard manure, and the average yield of the last three crops has been 400 bushels per acre, calculating the bushel to weigh 50 pounds. The manure used each year has been 300 pounds of sulphate of potash, 350 pounds of superphosphate of lime, and 400 pounds of salts of ammonia, while in another experiment, instead of the salts of ammonia, 540 pounds of nitrate of soda were applied. The produce from both manures has been almost identical.

"The sulphate of potash supplies about 130 pounds of potash—and we find very nearly the same amount in the crop. The phosphoric acid, on the other hand, is much in excess of the requirements of the crop, and it might be reduced one-half. The salts of ammonia and the nitrate each supply about the same amount of nitrogen—87 pounds

and of this the crop does not take up more than 50 pounds; there is, apparently, therefore, a considerable loss of this substance; but, at the same time, any reduction in the amount of these manures would be followed by a reduction in the crop. The loss of this costly manure ingredient is a most serious matter, as unfortunately there is but little prospect of recovering, in succeeding crops, any appreciable amount of the 37 pounds not taken up by the first. By means of the same mineral manures *alone*, we have grown—over the same period—one half the crop we obtained by the application of minerals with nitrogen, the soil having supplied a sufficient amount of that substance to give a product of 200 bushels; but one-half of the minerals applied remained inactive in the soil; these, however, might be made available to the crop by an application of nitrogen.

"The quantity of potash removed in potatoes is very large. In the 400 bushels it amounts to about 130 pounds. Compare this with the amount removed by animals. An ox, weighing 1,400 pounds, which was killed for the purpose of analysis, contained only two and one-half pounds, in the whole carcass and offal. Hay is another crop which takes a good deal of potash from the soil, and farmers in England rarely grow either hay or potatoes for sale, unless there are facilities for the purchase of town dung. Artificial manures are certainly not used alone, by practical farmers, in the growth of their crops.

"In our experiment field, the character of the manures is always represented in the stems and leaves of the plant. Ammonia and nitrate, without minerals, give a low stem and greenish-brown leaves, which in the evening appear almost black. Minerals without nitrogen, give a thin, low stem and yellowish-green leaves, while minerals and nitrogen together give a luxuriant, and sometimes an over-luxuriant, stem with leaves of a bright green. There is no difficulty in accounting for these peculiarities. A plant takes up whatever food is most abundant in the soil, with the hope, as I sometimes put it, that sooner or later it may find the food which suits it best. In the dark green leaves the nitrogen is in excess, but starch cannot be formed without potash, and the supplies of potash are not sufficient to use up the nitrogen. It is far more easy to change yellowish-green of the mineral-manured potatoes into a dark green, than it is to lighten the color of potatoes which receive nitrogen; a solution of nitrate of soda will effect the one in a very few days, but as both

potash and phosphoric acid form insoluble compounds with the soil, they are much more slowly taken up by plants.

"We always, however, obtain a larger crop of potatoes where we apply the mineral manures alone, than where we apply the nitrogen without the minerals, though in the next field, salts of ammonia, applied without minerals for 39 years in succession, have grown larger crops of wheat over the whole period than mineral manures without ammonia. To explain this apparent inconsistency we must consider the great difference in character of the two crops.

"Wheat in England is sown in the autumn, and being a deep-rooted plant, it has a greater range of soil to obtain a supply of mineral food than the spring-sown potato. The relation between the potash and the phosphoric acid and nitrogen in the two crops is also very different. In the wheat crops grown by salts of ammonia alone, mixed samples, taken over a period of 10 years, give the products per acre of the total crop--straw and grain—as follows: nitrogen, 36 pounds; potash, 23 pounds; phosphoric acid, 13 pounds. The relation, therefore, between these two important minerals and nitrogen is as 1 to 1.

"In the potato crop, on the other hand, the proportion of nitrogen to the minerals is nearly 1 of nitrogen to 3 of minerals, the demand upon the soil for potash being much greater in the case of potatoes than where wheat or barley is grown. It must be a very large wheat crop indeed which removes 50 pounds of nitrogen from the soil, but in some of our potato crops we carry off more than 100 pounds of that substance per acre.

"As very few soils could furnish so large an amount as this from their own resources, when potatoes are continuously grown, it becomes necessary to furnish a supply of potash either in dung or chemical salts. The following table gives the products of the crop grown in 1883, being the ninth in succession without any change in the manures

TABLE.

		Potatoes per acre in long ton.	*Cwt.*
1.	14 tons of dung	6	
2.	Minerals without nitrogen	5	
3.	Nitrogen without minerals	3	3
4.	Minerals and ammonia	8	19
5.	Minerals and nitrates	8	2

Amount of mineral matter and nitrogen per cent. in dry tubers.

	Mineral matter.	Nitrogen.
1	3.5	1.09
2	3.86	0.73
3	2.64	1.47
4	3.67	1.08
5	3.86	1.37

"The character of the manure is most clearly shown in the composition of the crop. In No. 2, manured with minerals, the minerals are more than five times as high as the nitrogen; while in No. 3, where ammonia or nitrates are used, the minerals are considerably less than double the amount of nitrogen. In both cases there is a waste of power, shown by small crops, and unused manures. The loss, however, is not equal in both cases, as the minerals remain in the soil, to be taken up at some future time, while the nitrogen is probably lost."

RESULTS OF EXPERIMENTS AT ROTHAMSTED (ENGLAND) ON THE GROWTH OF POTATOES FOR TWELVE YEARS IN SUCCESSION ON THE SAME LAND.

Dr. J. H. Gilbert, Dr. Lawes's associate, in a lecture before the Royal Agricultural College speaks at considerable length on the above subject.

His special object was to show the general requirements of the crop, both actually and as compared with other crops, and the actual and comparative characters and composition of the product obtained. He draws his illustrations mainly from the results of field experiments on the growth of the potato by different manures, for a number of years in succession on the same land, at Rothamsted, and from those of collateral investigations into the composition of the produce, made in the Rothamsted laboratory.

The average produce over twelve years without manure is not quite two tons per acre; and there was considerable decline from period to period under this exhausting treatment. Nevertheless this low yield without manure for twelve years in succession on the same land, is about as much as the average produce under ordinary cultivation

in the United States, and nearly two-thirds as much as in some important European countries. By superphosphate of lime alone, the produce is raised from an average of scarcely two, to nearly 3¾ tons; that is, to very little more than by the superphosphates alone. It is evident, therefore, that up to this amount of production, the character of the exhaustion induced by the growth of the crop on this land, which was, agriculturally speaking, in a somewhat exhausted condition, was much more that of available phosphoric acid than of potash, or the other bases. It is remarkable that there is much less increase of produce of potatoes by nitrogenous manures than by mineral manures alone.

Thus, by ammonium salts alone there is an average produce of scarcely two tons six cwts., or only about six cwts. more than without manure; and with nitrate of soda alone there is an average of only two tons 12½ cwt. per acre. The better result by nitrate of soda than by ammonium salts is doubtless due to the nitrogenous supply being more immediately available, and more rapidly distributed within the soil, and so inducing a more extended development of the feeding root.

These negative results by the nitrogenous manures alone, confirm the conclusion that by the continuous growth of the crop on this land it was the valuable supply of mineral constituents within the root range of the plants, more than that of nitrogen, that became deficient.

The last two lines of the table show that, with the mixed mineral manure and ammonium salts together, there was an average of about six tons 14½ cwts., and with the mixed mineral manure and the same amount of nitrogen as nitrate of soda, an average of six tons 13 cwt.; that is, nearly twice as much as with the mineral manure alone, and much more than twice as much as with the nitrogenous manure alone.

The fact is, that it is only the comparatively small proportion of the nitrogen of farm-yard manure, which is due to the liquid dejections of the animals, that is in a readily and rapidly available condition; whilst that due to more or less digested matter passing in the fæces, is more slowly available, and that in the latter remains a long time inactive. Hence, the addition of nitrogen as nitrate of soda to the farm yard manure had a very marked effect.

The summary shows that the proportion of diseased tubers was the greater, the greater the amount of nitrogen supplied.

Upon the whole, it is obvious that in the case of this somewhat agriculturally exhausted arable land, mineral manures alone had more effect than nitrogenous manures alone ; but that, mineral constituents being adequately supplied, the further addition of nitrogenous manures was essential to obtain anything like full crops.

It is of interest to observe that the amount of disease was not enhanced by the continuous growth of the crop on the same land, as is frequently assumed to be the case.

But little is definitely known of the special function of individual mineral constituents in vegetation. It is, however, pretty clearly established that the presence of potash is essential for the formation of the chief non-nitrogenous matters—starch and sugar. The published results of experiments at Rothamsted have shown that the proportion of potash in the ash of wheat was the greater, the better matured the grain—that is, the larger proportion of starch it contained ; and here in the potato we find a greatly increased amount of potash in the heaviest crops, that is to say, in those in which the largest amounts of starch have been formed.

The accumulation of phosphoric acid, on the other hand, is more directly connected with the assimilation of nitrogen and the formation of the nitrogenous compound.

It will be remembered that the quantity of farm-yard manure annually applied per acre was estimated to contain about 200 pounds of nitrogen, besides a very large amount of mineral constituents. Yet, in no case was the increased yield of solid substance in the crop so great as was obtained by an artificial mixture of mineral and nitrogenous manure, supplying only 86 pounds of nitrogen, but in a more readily available condition. Nor was the increased assimilation of any of the individual constituents so great under the influence of the farm-yard manure, as when they were applied in the rapidly available condition, as in the artificial mixtures.

In the case of other crops it has been found that only a small portion of the nitrogen of farm-yard manure was taken up in the year of application. But these results seem to indicate that *the potato is able to avail itself of a less proportion of the nitrogen of the manure than any other farm crop.* Yet, in ordinary practice, farm-yard manureis

not only largely relied upon for potatoes, but is often applied in larger quantities for them than for any other crop. It is probable, that independent of its liberal supply of all necessary constituents, its beneficial effects are in a considerable degree due to its influence on the mechanical condition of the soil, rendering it more porous and easily permeable to the surface roots, upon the development of which the success of the crop so much depends. Then, again, something may be due to an increased temperature of the surface soil, engendered by the decomposition of so large an amount of organic matter within it; while the carbonic acid evolved in the decomposition will, with the aid of moisture, serve to render the mineral resources of the soil more soluble.

In countries where the potato is largely grown for the manufacture of starch, the specific gravity serves as an important indication of quality. The higher the specific gravity, the greater, as a rule, is the proportion of dry matter, and the greater the proportion of starch. Indeed, tables are constructed for the calculations of the percentage of dry matter, and of starch from the specific gravity of the tubers.

The general conclusion to which these calculations as to the distribution of the various constituents of potato tubers leads is, that from 80 to 85 per cent., or even more, of the total nitrogen of the tubers may be in the juice, and that about the same proportion of the total mineral matter also may be in the juice. Further, that about the same proportion—80 to 85 per cent.—of the total potash, and about two-thirds of the total phosphoric acid, are in the juice. And when it is borne in mind that two-thirds, or more, of the nitrogen existing as albuminoids is in the juice, it is obvious that if the mode of cooking the potato is such as to exclude the constituents of the juice from the final food product, there is considerable waste of nutritive matter; and that, indeed, the proportion of albuminoid matter in the food is exceedingly small. When potatoes are used as a mere adjunct to an otherwise liberal diet, the general practice is to cut off the rind, and to put the peeled potatoes into cold water, by which a large proportion of the soluble albuminoid matters must be washed out, before the temperature of the water becomes sufficiently high to coagulate and fix them. A very large proportion of the potash must also be washed out under such circumstances. When, however, potatoes constitute an important item in the diet, as in the ru

ral districts of Ireland, for example, it is usual to boil them in their skins, or, as it is said, in their jackets. Under such circumstences, certainly a much larger proportion of the albuminoid matter will reach the stomachs of the consumers ; and doubtless much more of the potash and phosphoric acid also. Still, it is obvious that a potato diet must be very deficient in the proportion of nutritive nitrogenous compounds.

The produce of dry substance of tubers was, without manure, 1,353 pounds per acre ; with purely mineral manure, 2,384 pounds ; and with the mixture of the mineral and nitrogenous manures ("complete") more than 4,000 pounds per acre.

Potatoes are reckoned to contain on an average more than 21 per cent. of starch.

The produce of starch per acre is 1,120 pounds without manure, and 1,988 or nearly 2,000 pounds with purely mineral manure—that is without nitrogen. The amount with purely nitrogenous manure is not so great as that with purely mineral manure. But with both nitrogenous and mineral manure ("complete") the quantity of starch is raised to an average of about 3,400 pounds, or about 1½ ton per acre.

CHAPTER VIII.

The Effects of Different Quantities of Fertilizers and Manures.

FERTILIZERS VERSUS MANURES.

ON NO other crop have we had such telling results from the use of chemical fertilizers, as compared with farm manure, as upon potatoes, and this has been the case during the past twelve years without any exception that is now recalled. This seems to have been the experience of many other farmers. Upon oats and corn, and vegetables of various kinds, fertilizers have occasionally failed to increase the crop, while farm manures in contiguous plots have produced marked effects. The experiments which we now have to record are no exceptions, though all the conditions seemed favorable to a decided and impartial test.

The land (a sandy loam) had never received any chemical fertilizers, and, for 15 years at least, no manure of any kind. Two plots were measured off, one-tenth of an acre each, that is 132x33 feet. The first received three tons of stable manure, or at the rate of 30 tons to the acre in October. The seed potatoes (Great Eastern) were cut to two eyes each and planted April 22, in drills 2½ feet apart, and 14 inches apart in the drills. Both plots were cultivated once and hoed twice, the soil being kept level without any hilling up about the plants. The yield was 24 bushels and 3 pecks, or at the rate of 247.50 bushels to the acre, of which 80 per cent. were marketable.

The second plot received instead of the stable manure 200 pounds of potato fertilizer, or at the rate of one ton to the acre, the seed pieces, distance of planting and treatment being just the same as

with the first plot. The yield was 27½ bushels, or at the rate of 275 bushels to the acre, of which 90 per cent. were marketable. The potatoes were smoother and brighter and less injured by wire worms than those of the manure plot.

The cost of the manure delivered was three dollars per ton, or nine dollars for the plot. The cost of the potato fertilizer was $48 per ton, or $4.80 for the plot. The guaranteed analysis of the latter was, ammonia, 4.50 to 5 per cent; phosphoric acid, 8 to 10 per cent; potash, 6 to 8 per cent., magnesia, lime, soda, etc., forming the rest.

The season was unfavorable throughout.

If potatoes had been raised on the same plots the next year without fertilizer or manure, possibly or even probably the manured plot would have outyielded the fertilized plot, because if for no other reason, the nitrogen of the latter, being soluble, would have passed through the soil, while the farm manure would have yielded nitrogen for that and subsequent seasons.

THE EFFECTS OF INCREASING QUANTITIES OF FERTILIZERS ON LAND MORE OR LESS IMPOVERISHED.

What amount of potato fertilizer can I use profitably on my land for this crop? By potato fertilizer is meant that which is sold as such by leading fertilizer manufacturers, costing from $40 to $45 per ton, and analyzing about four per cent. of nitrogen, ten per cent. of phosphoric acid, and seven per cent. of potash. It is a question which a farmer must answer for himself, and that the question may be answered it is the object of these experiments to show. My experiment land, as has been shown, needs all kinds of plant food. Nothing less than a "complete" potato fertilizer will materially increase the crop. For example, if the above fertilizer be deprived of either potash, nitrogen or phosphoric acid, no matter in how great quantities the remainder is applied, no material increase in the crop will be given. This is true of this particular land. Upon other farms, any one or two might increase the yield as much as if all were used, in which case the cost of the omitted ingredients would be saved. Whether special or complete fertilizers will prove more profitable depends entirely upon what the land needs, and this vital question is what each farmer must find out for himself.

The trenches were dug about a foot wide and four inches deep, as in most of the potato experiments herein recorded. The seed pieces were placed in the bottom, exactly a foot apart, and lightly covered with soil, and the various quantities of fertilizers as stated in the following tables were evenly strewn in the trenches. The fertilizer used in this series of experiments was the "Stockbridge Potato Manure," the analysis and cost of which are approximately given above. The variety planted was the Rural Blush.

FIRST SERIES.

No. 1. 220 pounds to the acre. The yield was at the rate of 276.83 bushels to the acre.

No. 2. 440 pounds of fertilizer to the acre. Yield, 330 bushels to the acre.

No. 3. 880 pounds of fertilizer. Yield, 397.83 bushels to the acre.

No. 4. Natural soil. The yield was at the rate of 163.16 bushels to the acre.

No. 5. 220 pounds of fertilizer to the acre (duplicate of No. 1). The yield was at the rate of 245.66 bushels to the acre.

No. 6. 440 pounds of fertilizer to the acre (duplicate of No. 2). The yield was 370.33 bushels to the acre.

No. 7. 880 pounds of fertilizer to the acre (duplicate of No. 3). The yield was at the rate of 476.66 bushels to the acre.

Averaging the two separate trials, we have :

220 pounds	fertilizer.	Yield	261.24	bushels.
440 "	"	"	350.16	"
880 "	"	"	437.24	"
Natural soil.		"	162 16	"

It appears, then, that 220 pounds of this fertilizer strewn in the trenches, as above explained, increased the yield over the unfertilized soil at the rate of 98 bushels to the acre : 440 pounds, 187 bushels ; 880 pounds, 274 bushels.

The above experiments show that thus far 880 pounds of the fertilizer may profitably be used to the acre. How much more than that amount can be profitably used will be shown in the next trials in which the comparative results of stable manure are also given. The promise of the yields, as judged by the growth and appearance of the

vines, is shown by ratings made by two persons, June 27. Ten (10), as in trials previously reported, was fixed as the highest rating.

Plot	1,	rated June 27	(220	pounds	fertilizer),	4.
"	2,	"	"	440	"	"	6.
"	3,	"	"	880	"	"	8.
"	4.	"	"	000	"	"	2

DUPLICATES.

Plot	5,	rated June 27	(220	pounds	fertilizer),	5.
"	6,	"	"	440	"	"	7.
"	7,	"	"	880	"	"	9.

SULPHATE OF IRON HARMFUL.

In this experiment Williams, Clark & Co.'s potato fertilizer was used, the minimum guaranteed analysis being ammonia four per cent., soluble phosphoric acid five per cent., potash eight per cent.

No. 1 received at the rate of 19,800 pounds of New York stable manure per acre. The yield was at the rate of 328.16 bushels to the acre.

No. 2 received neither manure nor fertilizer. The yield was 212.66 bushels to the acre.

No. 3 received 440 pounds of the fertilizer. The yield was 245.66.

No. 4 received 880 pounds. The yield was 330 bushels.

No. 5 received 880 pounds of the fertilizer and at the rate of 440 pounds to the acre of *sulphate of iron*. The yield was 309.83 bushels to the acre.

No. 6 received 1,320 pounds of the potato fertilizer. The yield was at the rate of 388.66 bushels to the acre.

No. 7 received 1,320 pounds of the potato fertilizer with 440 pounds of the *sulphate of iron*. The yield was 379.50 bushels.

No. 8 nothing. Yield 264.00—the highest yield ever made in this particular soil without manure or fertilizer.

No. 9 received 1,760 pounds of the potato fertilizer. Yield, 443.66.

No. 10 received 2,200 pounds to the acre of the potato fertilizer. The yield was nearly the same as No. 9, viz., 443 bushels. No. 11 received 2,640 pounds. The yield was 480.33.

No. 12 received at the rate of 880 pounds of the potato fertilizer and also 200 pounds of ground fish, 660 pounds of kainit, 440 of bone

flour, and 440 pounds of nitrate of soda—2,640 pounds to the acre in all. With this excessive application of all kinds of plant food, but especially of nitrogen, the yield was 361.16 bushels to the acre.

In this experiment the yield is profitably increased by this fertilizer up to 1,760 pounds to the acre. The tabulated figures are:

440 pounds fertilizer		245.66 bushels.	
880	" "	330.00	"
1,320	" "	388.66	"
1,760	" "	443.66	"
2,200	" "	443.00	"
2,640	" "	480.33	"

That No. 8 without any fertilizer should have yielded more than No. 3, which received 440 pounds to the acre, cannot be accounted for. That 2,200 pounds gave no greater yield than 1,760 pounds, while 2,640 pounds largely increased the yield over either, is also inexplicable.

The copperas decreased the yield in both trials.

As in previous trials of the several plots, as judged by the growth and appearance of the vines, the promise of yield is shown by ratings made by two persons June 27, ten (10) being the highest.

No. 1	Rated 5	1,980 lbs. stable manure.
" 2	" 3	Nothing.
" 3	" 4	440 fertilizer.
" 4	" 6	880 "
" 5	" 6	880 "
" 6	" 8	1,320 "
No. 7	Rated 8	1,320 fertilizer. 440 sulphate of iron.
" 8	" 3	Nothing.
" 9	" 10	1,760 fertilizer.
" 10	" 10	2,200 "
" 11	" 10	2,640 "
" 12	" 8	2,640 mixed fertilizer.

HOW MUCH FERTILIZER MAY BE PROFITABLY USED FOR POTATOES ON AN IMPOVERISHED SOIL THAT NEEDS "COMPLETE" FERTILIZER?

The soil on which these experiments have been carried on for the past *two* years is so impoverished that the yield by the most careful trench culture without fertilizer is less than 150 bushels of potatoes

to the acre, while paying crops of corn or vegetables of any kind are out of the question. Fertilizer has been used from 400 to 2,200 pounds to the acre for two seasons on this particular plot, and for four other seasons on two other fields, and the results have been essentially the same, whether the weather has been wet or dry. The variety was the Rural Blush. The season was the wettest ever known.

FIRST SERIES.

Plot 1.	Natural soil	161.33	bushels	per acre
" 2.	440 pounds fertilizer	190.66	"	"
" 3.	880 "	212.66	"	"
" 4.	1,320 "	278.66	"	"
" 5.	1,760 "	330.00	"	"
" 6.	2.200 "	308.00	"	"

SECOND SERIES.

Plot 7.	Natural soil	154.00	bushels	per acre.
" 8.	440 pounds fertilizer	187.00	"	"
" 9.	880 "	216.33	"	"
" 10.	1,320 "	245.66	"	"
" 11.	1,760 "	297.00	"	"
" 12.	2,200 "	330.00	"	"

THIRD SERIES.

Plot 13.	Natural soil	117.33	bushels	per acre.
" 14.	440 pounds fertilizer	128.33	"	"
" 15.	880 "	198.00	"	"
" 16.	1,320 "	282.33	"	"
" 17.	1,760 "	300.00	"	"
" 18.	2,200 "	344.66	"	"

FOURTH SERIES.

Plot 19.	Natural soil	146.66	bushels	per acre.
" 20.	440 pounds fertilizer	165.	"	"
" 21.	880 "	238.33	"	"
" 22.	1,320 "	304.33	"	"
" 23.	1,760 "	249.33	"	"
" 24.	2,200 "	363.00	"	"

AVERAGES.

Natural soil	144	bushels per acre.
440 pounds fertilizer	168	" "
880 "	216	" "
1,320 "	278	" "
1,760 "	294	" "
2,200 "	336	" "

Rot prevailed more than ever before. The rotten potatoes were not estimated. The vines were injured by the flea-beetle and died nearly one month earlier than usual. The tubers seemed to be about three-quarters of the normal size.

It would seem that farmers cultivating impoverished land should learn a valuable lesson from these experiments, which have been conducted long enough to prove that there is a reasonable chance of raising profitable crops of potatoes by the liberal use of high-grade fertilizers. The guaranteed analysis of the fertilizer used is as follows:

Ammonia	4½	per cent.
Phosphoric acid	8 to 10	"
Potash	6 to 8	"

EFFECTS OF DIFFERENT QUANTITIES OF FERTILIZERS ON POTATOES GROWN IN A VARIABLE SOIL.

Plot 30—	220 pounds, yielded at the rate per acre of	258.50	bushels.
" 36—	220 "	205.33	"
" 40—	220 "	172.33	"
" 31—	440 "	298.83	"
" 37—	440 "	253.	"
" 41—	440 "	253.	"
" 32—	880 "	282.33	"
" 38—	880 "	227.	"
" 42—	880 "	231.	"
" 33—	1,320 "	228.16	"
" 44—	1,320 "	242.	"
" 34—	1,760 "	280.	"
" 39—	1,760 "	242.	"
" 43—	000 "	161.33	"
" 35—	000 "	132.	"

SUMMARY.

The average crop of the plots that did not receive any fertilizer was at the rate per acre of	146.66	bushels.
220 pounds gave	212.05	"
440 " "	268.28	"
880 " "	246.78	"
1,320 " "	285.08	"
1,760 " "	261.	"

The variety planted was the Rural Blush. Some of the vines were greatly, some lightly, and a few not at all, injured by the flea-beetle.

The fertilizer used was the Stockbridge potato manure.

ON AN ADJACENT PLOT.

These trials as to the effects of increasing amounts of fertilizers were again carried on during the past season—1890. The season was remarkable for the amount and frequency of rainfall and for comparatively few potato beetles. Flea-beetles were less numerous and blight less destructive than during the two preceding seasons. The plots have never (so far as the writer can ascertain) received any manure or fertilizer of any kind prior to the last three years, when these potato experiments were begun on this particular land. The soil is variable, being in parts a stiff clay while in other portions it is more of a loamy character. Mapes' potato fertilizer, the analysis of which has been given, was used in quantities at the rate of from 220 to 1,760 pounds to the acre. The trenches and culture given were the same as in preceding trials, the variety Rural Blush.

Plot 1—	220 pounds to the acre	yield	156	bushels.
" 6—	220 " "	"	139	"
" 2—	440 " "	"	187	"
" 7—	440 " "	"	176	"
" 3—	880 " "	"	229.16	"
" 8—	880 " "	"	210.83	"
" 4—	1,760 " "	"	313	"
" 9—	1,760 " "	"	298.80	"
" 5—	Nothing	"	196.16	"

AVERAGES.

No fertilizer gave per acre	196.16	bushels.
220 pounds fertilizer gave per acre	147.50	"
440 " " "	181.50	"
880 " " "	219.99	"
1,760 " " "	305.90	"

TOTAL AVERAGES.

No fertilizer yielded per acre	187.77	bushels.
220 pounds fertilizer yielded	206.93	"
440 pounds fertilizer yielded	242.72	"
880 pounds fertilizer yielded	290.00	"
1,320 pounds fertilizer yielded	317.25	"
1,760 pounds fertilizer yielded	326.14	"
10 tons (nearly, viz., 19,800 lbs.) stable manure yielded	328.16	"
30 tons stable manure yielded, in a less favorable season,	247.50	"
Average of stable manure	287.83	"

In what way is our friend, the reader, to turn the above experiments to his own advantage? Were his land the same he would naturally reason in this wise: "The natural soil, I find, may be relied upon to give 188 bushels to the acre. To be on the safe side I will estimate their market value at 50 cents the bushel. That would give $94 worth of potatoes to the acre. Now, 220 pounds of fertilizer costing $4.40 (or $40 per ton) gives an increase of 19 bushels, which at 50 cents the bushel are worth $9.50. I am a gainer, for the use of the fertilizer, of $9.50 per acre, less $4.40, or $5.10 per acre. If I use 440 pounds of fertilizer I am, by the same figuring, a gainer of $27.50. If I use 880 pounds of fertilizer I gain $51.00; 1,320 pounds, $64.50; 1,760 pounds, $69.00, not to consider the advantage which will accrue to succeeding crops by excessive applications."

But the chances are largely against the assumption that his land is the same, or so nearly the same, that he would be safe in adopting the above conclusions as safe to work upon. There is not one to ad-

vise him wherein he should proceed differently. Analysis of his soil would not be an infallible guide. The brightest agricultural chemist in the world could give him no positive information as to the kind and quality of fertilizer which might be most economically used. Manifestly, therefore, he must become his own teacher, and he can do this in no other more effective way than by instituting a similar set of experiments on his own fields, guided by the intimations which stable, farm-yard, hen or other manure, ashes or other partial manures may have in past seasons afforded. In effectually carrying on such a series of simple investigations, subsequent parts of this book may be of assistance.

CHAPTER IX.

Shall the Fertilizer be Placed Under or Over the Seed Pieces?

IT IS not known to the writer that any effective experiments have been made to solve this seemingly important problem. If the old way—or ordinary way—of planting potatoes be pursued, viz., placing the pieces in a shallow plow-furrow and then throwing the furrow soil back, it may have little significance one way or the other. But if the trench system be followed, there might reasonably be expected a decided difference—a difference modified of course by rainfall—whether the applied food be below or above the pieces. The experiments were begun ten years ago for a single season, and resumed four years ago. The following plain tables will set forth the outcome up to this time. Evidently the trials should be made not only in light, medium and heavy soils, but for many years ere an emphatic answer could reasonably be looked for.

The trenches were dug about five inches deep, three feet apart, and a foot wide. The Stockbridge * potato fertilizer (880 lbs. to the acre) was spread under and over the pieces (Blush), separated from them in either case by two inches of soil. The season was favorable, being neither too wet nor too dry.

FERTILIZER UNDER.

No. 1,	per acre	359.33	bushels.
" 3,	" "	313.33	"
" 5,	" "	412.50	"
" 7,	" "	330.00	"

* The average analysis of this fertilizer is given as ammonia, five per cent, phosphoric acid, 10 per cent; potash, six per cent.

No. 9,	per acre	310.20	bushels.
" 11,	" "	335.50	"
" 13,	" "	297 00	"
" 15,	" "	392.33	"
" 17,	" "	289.66	"
" 19,	" "	289.66	"
		3,329.51	bushels.

Or at the average rate of 332.95 bushels to the acre.

FERTILIZER OVER.

No. 2,	per acre	359.33	bushels.
" 4,	" "	339.16	"
" 6,	" "	339.16	"
" 8,	" "	322.66	"
" 10,	" "	419.83	"
" 12,	" "	322.66	"
" 14,	" "	311.66	"
" 16,	" "	365.00	"
" 18,	" "	354.50	"
		3,133.96	bushels.

Or at the average rate of 348.21 bushels of potatoes to the acre. We have thus far a difference of over 15 bushels in favor of placing the fertilizer *above* the seed pieces.

UNDER AND OVER EXPERIMENTS CONDUCTED FOR THE SECOND YEAR.

The trenches were dug the same depth, viz., five inches. In the "fertilizer *under*" trials, the fertilizer was strewn in the bottom of the trenches and the seed pieces (Blush) placed on or in contact with the fertilizer. In the "fertilizer *over*" trials, the pieces were placed in the bottom of the trenches, and the trenches filled to within one inch. The fertilizer (the same as that used in the experiments recorded above) was then strewn on this soil in the trenches, at the rate of 1,300 pounds to the acre, and the remaining inch of the trench filled in and the soil leveled. Fractions are omitted in the results. The season was wet.

Plot 1,	fertilizer under	293	bushels per acre.
" 2,	" over	293	" " "
" 3,	" under	205	" " "
" 4,	" over	293	" " "
" 5,	" under	213	" " "
" 6,	" over	275	" " "
" 7,	" under	176	" " "
" 8,	" over	176	" " "
" 9,	" under	279	" " "
" 10,	" over	260	" " "
" 11,	" under	242	" " "
" 12,	" over	308	" " "

AVERAGE.

Under.............................. 235 bushels per acre.
Over.............................. 268 bushels per acre.

SHALL THE FERTILIZER BE PLACED UNDER OR OVER THE SEED PIECES? THIRD YEAR (1890).

The trenches were dug this times six inches deep. In the "fertilizer under" trials, the fertilizer was strewn in the bottom of the trenches, and the seed pieces (Rural Blush) placed on (in contact with) the fertilizer. In the "fertilizer over" trials, the pieces were placed in the bottom, as with the others, and five inches of soil were returned. Then the fertilizer was sown on this soil, the remaining soil (one inch) being replaced to fill the trench.

No. 1, fertilizer under; yield per acre	232.83
" 3, " " " "	253
" 5, " " " "	269.50
" 7, " " " "	255.65
" 9, " " " "	254.83
Average yield per acre	253.16

No. 2, fertilizer over; yield per acre	214.50
" 4, " " " "	225.50
" 6, " " " "	218.16
" 8, " " " "	245.66
" 10, " " " "	265.83
Average yield per acre	233.93

A difference in favor of placing the fertilizer *under*, of 19.23 bushels per acre. The fertilizer used in this and the preceding trial was the Mapes' potato, at the rate of 1,000 pounds to the acre. *The season was wet throughout*, one of the wettest remembered.

IN THE SEASON OF 1889,

which was also a wet season, and when the crop was thought to be lessened by the flea-beetle and blight, the average results were as follows, as above recorded.

Under yielded an average per acre of....	235	bushels.
Over " " "	268	"

A difference of 33 bushels per acre in favor of placing the fertilizer over.

DURING THE SEASON OF 1888,

Stockbridge potato fertilizer was used at the rate of 800 pounds to the acre, as also stated. The season was favorable as to rain-fall, it being neither too much nor too little, while the tops were not harmed by flea-beetles or blight :

Under yielded an average per acre of....	332.95	bushels.
Over " " "	348.21	"

We have a difference of 15.26 bushels per acre in favor of placing the fertilizer over.

A GENERAL SUMMARY,

of the averages for the three years shows as follows :

Fertilizer over, per acre............	283.38	bushels.
" under "	273.70	"
Difference in favor of fertilizer over..	9.68	"

CHAPTER X.

Results of Planting Potatoes in Trenches of Different Depths.

FIRST TRIALS.

THE soil of these plots, naturally variable, was made exceedingly so by grading, the soil from the higher parts having been carted to the lower places. It is in some parts a sandy loam, in others a clay loam, and in still other parts a stiff brick-clay, all impoverished by years of cropping without any manure of any kind. These potato experiments were in previous years made on plots of notably uniform soil, so impoverished that anything short of a "complete" fertilizer failed to materially increase the crops.

This was proven so conclusively that there seemed to be no reason why the trials should be continued upon them.

The following exhibit, as might well have been anticipated from the variability of the soil, seems to show that the depth of planting should be governed by the character of the soil. At the rate of 800 pounds of Stockbridge potato fertilizer was sown in the trenches after the seed pieces were lightly covered. The trenches were three feet apart, measuring in this trial, as in every other, from the middle of each.

Plot 21,	4 inches deep yielded........	403.33	bushels	per acre.
" 23,	" " "	348.33	"	"
" 27,	" " "	363.00	"	"

This gives an average, for four-inch deep planting, of 371.55 bushels to the acre.

Plot 20,	8 inches deep yielded........	385.00	bushels	per acre.
" 22,	" " "	300.66	"	"
" 26,	" " "	355.66	"	"
" 29	" " "	311.66	"	"

This gives an average per acre, for eight inches deep planting, of 338.24.

Plot 24,	10 inches deep yielded	......	267.66	bushels	per acre.
" 25,	" " "	......	381.33	"	"
" 28,	" " "	......	384.16	"	"

This gives an average per acre, for ten-inch deep planting, of 311.05 bushels.

SUMMARY.

Ten-inch planting....................	311.05	bushels
Eight-inch planting..................	338.24	"
Four-inch planting...................	371.55	"

The variety planted was the Rural Blush. Some of the vines were greatly, some slightly, and a few not at all injured by the flea-beetle.

IN 1889,

one of the wettest seasons known, the average results, much reduced by blight and the flea-beetle, were as follows :

Two inches, per acre	226	bushels.
Four " " "	220	"
Six " " "	185	"
Eight " " "	177	"
Ten " " "	148	"

TRIALS OF 1890.

The trenches were dug two, four, six, eight and ten inches deep, and the fertilizer was sown at the rate of 1,000 pounds to the acre in the trenches after the seed pieces had received an inch covering of soil. The fertilizer used was the Mapes potato, analyzing as follows: Ammonia, 4.50 per cent.; phosphoric acid, eight; potash, six; the minimum quantities guaranteed. The soil of these plots is naturally poor and thin—a loam inclining rather to clay than to sand. It has never received any manure in so far as the writer has been able to learn—certainly not within the past 19 years. The season was wet throughout. There were so few potato-beetles that it was necessary to apply Paris-green but once. Then it was sifted upon the vines—1½ pound to 200 pounds of plaster, thoroughly mixed together on a

tight board floor. The mass of plaster was first spread over the floor about two inches in thickness. The poison was then as evenly as possible sifted over this. It was then mixed by the use of a steel rake, shoveled into a heap, spread out again and raked, etc., until the distribution of the poison seemed to be perfect. There were few flea-beetles and no blight, though last year on this same land, flea-beetles destroyed the vines several weeks before their time of maturity. The variety, as in all previous trials, was the Rural Blush.

No.	*Inches.*	*Bushels per acre.*
1.	2	308.
2.	4	297.
3.	6	304.33
4.	8	247.50
5.	10	276.83
6.	2	249.
7.	4	287.83
8.	6	302.50
9.	8	265,83
10.	10	287.83
11.	2	260.
12.	4	238.33
13.	6	278.66
14.	8	223.66
15.	10	269.50
16.	2	260.
17.	4	261.83
18.	6	267.66
19.	8	227.33
20.	10	236.50
21.	2	280.50
22.	4	278.66
23.	6	315.33
24.	8	300.
25.	10	240.16
26.	2	242.
27.	4	293.
28.	6	254.83
29.	8	293.
30.	10	269.50

No.	*Inches.*	*Bushels per acre.*
31.	2	258.33
32.	4	284.17
33.	6	247.50
34.	8	251.16

AVERAGES.

Two inches depth yielded, per acre	265 40 bushels.
Four " " " " "	277.26 "
Six " " " " "	281.56 "
Eight " " " " "	258.35 "
Ten " " " " "	263.38 "

The difference between the greatest yield—six inches depth—and the smallest yield—eight inches depth—is 23.19 bushels to the acre. The difference between the eight inches depth and the ten inches depth is but five bushels to the acre. Had the season been dry we should naturally have looked for a larger yield from the deeper trenches. As it was, the difference does not at all pay for the extra cost of a depth of planting beyond six inches.

AVERAGE OF TOTAL RESULTS.

Two inches, per acre	245.70 bushels.
Four " " "	289.60 "
Six " " "	233.27 "
Eight " " "	257.86 "
Ten " " "	240.81 "

It will be seen that the four-inch trenches give the largest yield as the average of three years during which these experiments have been conducted. When it is considered that the eight-inch trenches give the next largest yield, we have evidence that the experiments have not been carried on long enough to warrant any positive generalizations.

CHAPTER XI.

Nitrogen, especially nitrate nitrogen as in nitrate of soda. Its effects when applied alone. May farmers derive a profit from its use when applied to land indiscriminately or as farm manure is applied? Joseph Harris's views and the author's answer. Experiments.

I HAVE always taken the view, with or without sufficient data for intelligent guidance, that unless the farmer or gardener by actual test, has found out that his land is poor in nitrogen and fairly supplied with potash and phosphoric acid, conditions which are known rarely to exist, he cannot afford to use the nitrate of soda alone except in a small, experimental way. The same may be said of sulphate of ammonia. This view I have taken pains to emphasize from time to time in several of the leading farm papers of the day. In a prominent horticultural magazine Mr. Joseph Harris, of Moreton Farm—the author of several interesting and very instructive books on farm topics—has criticised these opinions, as may be seen by the following remarks :

MR. HARRIS'S CRITICISMS.

"Mr. Carman says : 'It is much to be regretted that certain writers are advocating the use of nitrate of soda. Unless the land is well supplied with potash and phosphoric acid and needs nitrogen alone, nitrogen will not materially increase the crop.'

"This is a self-evident proposition. And the same thing might be said of soda, lime, magnesia, sulphuric acid and iron. All these ingredients of plants are absolutely essential to healthy plant growth.

"There are people who contend that to maintain the productive-

ness of our land it is necessary to return to the soil the amount of plant food that the crops remove. They overlook the fact that a certain amount of plant food is rendered available each year from the store of plant food lying dormant in the soil. If this is sufficient we need use no manure. If any one element is deficient, we must supply the deficiency or be satisfied with a deficient yield. The weakest link in a chain determines the strength of the whole chain. If we find out the weakest link and strengthen it, then some other link would be the weakest. As a rule, for most garden crops our soils are deficient, 1st, in nitrogen; and when this is supplied, they are deficient, 2nd, in phosphoric acid; and when this is supplied they are deficient, 3rd, in potash, and so on through every link in the chain.

"For forty years or more, efforts have been made to find out what ingredients of plant food are most likely to be deficient. It was proposed to analyze the soils. This was found to be practically useless. The idea was then advanced that the amount of plant food in the crops would tell us the amount necessary to apply in manure. Lawes and Gilbert's experiments, over forty years ago, demonstrated the fallacy of this idea, but every now and then it shoots up again and grows as vigorously and perniciously as ever.

"What we need, especially in garden crops, is not 'soil tests,' but experiments that will show what plants require a 'sap of the soil' specially rich in nitrogen or in phosphoric acid or potash. In other words, we want to ascertain the weakest link in the supply of food for different plants; and there is no way of getting at the facts except by actual experiments.

"When Mr. Carman says it is much to be regretted that we are advocating the use of nitrate of soda, he overlooks the fact that we advocate the use of superphosphate with equal earnestness, and, in some cases, of potash also. The object of these articles was to show that when gardeners use the ordinary commercial fertilizers, they spend a great deal of money for plant food that their crops do not need. For instance, if they want to apply 100 pounds of nitrogen on an acre of land, and 50 pounds of phosphoric acid, and buy a fertilizer guaranteed to contain 2 per cent. of nitrogen and 12 per cent. of phosphoric acid, they will have to sow 5,000 pounds to the acre, and this will furnish *twelve times* as much phosphoric acid as is required. What we contend for is that they should buy the necessary phos-

phoric acid in the cheapest and best form and be sure to use enough of it, but not too much. To put on twelve times as much soluble phosphoric acid as is needed, in order to get the necessary nitrogen, is folly. If you want nitrogen as well as phosphoric acid, buy the nitrogen in the cheapest and best form. If we recommend nitrate of soda to those who wish to buy nitrogen, it is because the nitrogen is in the best and most available form, and because, at the present time, it is the cheapest source of nitrogen.

"There are enormous beds of it in South America, and its use in Europe is rapidly increasing, while with us it is almost unknown. It certainly is well worth our while to see if, especially in our dry and sunny climate, we cannot use it to great advantage.

"Mr. Carman further says: 'In experiments made at the Rural Grounds during two seasons, to ascertain the effect of nitrogen on potatoes, it was found that additional quantities of nitrate of soda, or sulphate of ammonia, or blood, or all three, beyond what was supplied by the 'complete' fertilizer, did not increase the yield in any case. * * * From 1,200 to 2,000 pounds of the fertilizer was used, guaranteed to contain 3½ per cent. of nitrogen, 12 per cent. of phosphoric acid and 6 per cent. of potash. It appears, therefore, that the amount of nitrogen supplied by the fertilizer was amply sufficient for the crop's needs, and that the added nitrogen was so much money thrown away.'

"Mr. Carman made better experiments than his allusion to them above would indicate. Our own personal objection to them is that they were on too small a scale to carry conviction to an old farmer and gardener. The plots were only $\frac{1}{440}$ part of an acre each. One good feature, however, was that four plots were left without manure. These plots produced at the rate of 88, 97, 68 and 59 bushels per acre each. The variation in the land, therefore, was 38 bushels per acre. Bearing this fact in mind, let us look at some of the more important results bearing on the subject we are discussing.

"RESULTS OF EXPERIMENTS ON POTATOES BY E. S. CARMAN.

	Bushels per acre.
"1—No manure (average 4 plots)	74
2—300 pounds sulphate of potash	95
3—400 pounds superphosphate	103

	Bushels per acre.
"4—200 pounds nitrate of soda	141
5—1,100 pounds blood, nitrate of soda and sulphate of ammonia	183
6—10 tons two-year-old farm manure	139
7—200 pounds nitrate of soda 120 pounds nitrate of potash	139
8—200 pounds nitrate of soda 120 pounds muriate of potash 700 pounds superphosphate	156

"There is certainly nothing in these results contradictory to the principles we have advocated. Mr. Carman states that the soil had been cropped for many years without manure of any kind, and that it 'would not grow beans, or even a good crop of weeds without manure.' And yet it will be seen that nitrogen *alone*, on plot 5, produced 183 bushels of potatoes per acre, while on plot 8, 1,020 pounds of a 'complete manure' produced only 156 bushels, or 27 bushels less than nitrogen alone. Why is this? Did the phosphoric acid and potash do harm? No; there was not nitrogen enough. The phosphoric acid and potash could not increase the crop for lack of nitrogen.

"Mr. Carman tells us that he used from 1,200 to 2,000 pounds of a complete fertilizer, guaranteed to contain 3½ per cent. of nitrogen, 12 per cent. phosphoric acid and 6 per cent. of potash, and that when he added *more nitrogen*, it did no good. Why should it! Oats are good for horses, but when a horse has all the oats he will eat, throwing more oats in the manger will not increase his strength or improve his appearance. If the ton of complete fertilizer furnished all the nitrogen the plants wanted, more could do no good. But for the sake of getting 70 pounds of nitrogen, what folly it is to use a ton of fertilizer that contains a greal deal more phosphoric acid, costing 8 cents per lb., than the crop can possibly want? This is the point we wish to impress on our readers. And it is a matter of surprise that so clear-headed and able a man as Mr. Carman does not see that his own experiments demonstrate, if they demonstrate anything, that, so far as the production of potatoes is concerned, this worn out soil, that was so poor that it would not grow a good crop of weeds, was more deficient in available nitrogen than in any other constituent

of plant-food. Superphosphate and potash, without nitrogen, did no good. They could produce no effect from lack of nitrogen. Thirty-two pounds of nitrogen per acre, in the form of nitrate of soda, raised the crop from 74 bushels per acre (or possibly 59 bushels) to 141 bushels per acre. The same amount of nitrogen on plot 8, in 1,020 lbs. of 'complete manure' produced 156 bushels, the 820 lbs. of superphosphate and potash only increasing the yield 15 bushels per acre—not as much as the difference in yield of the unmanured plots. Nitrogen alone, on plot 5, produced 183 bushels per acre. It is clear, therefore, that a complete manure, like that used on plot 8, containing about 3¼ per cent. of nitrogen, is a very costly and 'badly balanced ration' for potatoes. It does not, for Mr. Carman's poor, worn-out soil, contain half nitrogen enough. It is true that by using enough of it you could grow a large crop, but it would be done at a fearful and unnecessary expense. We feel perfectly safe in saying that a ton of it per acre would produce no larger a crop than half a ton that contained double the amount of nitrogen.

"A complete manure, such as that used on plot 8, would probably cost $40 per ton. The 200 lbs. of nitrate of soda in the mixture can be bought for $5. In other words, the phosphoric acid and potash in the ton of this complete manure cost $35. Leave half of it out and double the nitrate and you will, in my judgment, get quite as large a crop at far less cost. There is nothing in Mr. Carman's experiments, or any other, to lead me to suppose otherwise.

"*Moreton Farm.* JOSEPH HARRIS."

REPLY TO JOSEPH HARRIS.

Mr. Joseph Harris's views are no doubt as sound as a dollar in the general principles which they advocate; but the instances which he cites in proof of his conclusions are possibly open to criticism.

For a year or so past certain writers have advocated a more generous use of nitrate of soda, in a way to lead those who have given little thought to chemical fertilizer questions to assume that it is in itself a fertilizer which will insure a profitable increase of crop, regardless of the needs of the soil. I have therefore repeatedly cautioned my readers not to use nitrate of soda (or nitrogen in any soluble form) unless it is known that the land is already proportionately supplied with available phosphoric acid and potash. Nitrogen

is neither more nor less valuable to the gardener or farmer than is either of the others. It is by far more costly, and, while the phosphates and potash remain in the soil for subsequent crops, nitrate of soda leaves us even before the current crop is harvested. We do not need to tell our distinguished critic this. He knows it, and has taught it in his writings for many years. And yet we place Mr. Harris among those who, while cracking up nitrate of soda, has *not*, in every case or in most cases, emphasized sufficiently the insuperable importance of a corresponding supply of minerals.

Mr. Harris assumes that the chemical fertilizers of to-day contain too small a quantity of nitrogen; that the minerals (potash and phosphate) are the strong links, and that a deficiency of nitrogen is the weak link of the chain by which the crop, in due proportion, will be diminished. This is true without a doubt in a majority of cases, and it is well that it is true, for if the farmer is to lose a part of the money he pays for fertilizers, he would better invest it in food constituents of a lower cost which will remain in his soil, than in nitrogen at a higher cost, which takes its leave after a single season of service. If a farmer, from experimentation, is fairly confident that his land is especially short in nitrogen, let him buy fertilizers with a high ratio of nitrogen; but if he knows nothing about it, the very best thing he can do is to buy high-grade complete fertilizers and use them until by experiment he finds that more nitrogen will profitably augment his crops. Then he may wisely add nitrate of soda, salts of ammonia or organic nitrogen, as he, by trial in an inexpensive way on small plots here and there, may find them serviceable. The advocacy of the use of one-sided, low-priced fertilizers on the part of the mixers ("manufacturers") and their agents, has done incalculable harm in the way of inducing those who till the soil to purchase fertilizers which do not furnish the full or partial meal which their land demands. The consequence is that they denounce fertilizers *in toto*. Thus, bone or South Carolina rock, kainit, superphosphates, ammoniated superphosphates, sold under high-sounding, taking names, and prices far below those of high-grade brands, are tried and condemned, not for what they really are, but as "*fertilizers*" which are assumed to furnish everything in the way of plant food that the name represents. So it is that in every case gifted and well-known writers, like Mr. Harris, whose words of advice are taken without question, should place all

possible emphasis upon the economy of purchasing either high-grac complete fertilizers, or of "incomplete" fertilizers only as the farm or gardener has learned from experiment that his land responds full to bone, to potash or to nitrogen, and that the other constituents ar not at present needed.

Mr. Harris says that it is a matter of surprise that I do not se that my own experiments demonstrate that, so far as the productio of potatoes is concerned, my worn-out soil was more deficient in nitro gen than in any other constituent of plant-food. "Superphosphate anc potash, without nitrogen, did no good. They could produce no effect without nitrogen. Nitrogen alone on one plot produced 183 bushels per acre," or, I may, add, 105 bushels above the *average* of the plots of natural soil *without* fertilizer. It is true that if this single trial be taken as a basis for comparison, Mr. Harris's reasoning is logical enough. It should be stated in fairness, however, that this little nitrogen plot yielded more for some reason than any other nitrogen-plot either of that year's experiments or of those of preceding years. Another plot which received not only the same quantity of nitrate of soda per acre (200 pounds), but also 200 pounds of sulphate of potash, produced but 90 bushels of potatoes to the acre, or 12 bushels above the natural-soil plots. Again, raw bone (1,100 pounds), furnishing perhaps three or four per cent. of ammonia, gave but 77 bushels per acre. Again, in our similar experiments of the year be-fore, nitrate of soda (200 pounds) gave a yield but little more than the average of the natural-soil plots. The several no-fertilizer plots yielded an average of 143 bushels to the acre. Nitrate of soda (200 pounds) yielded but 125 bushels, sulphate of ammonia (120 pounds) yielded the same, nitrate of soda (200 pounds) and dissolved bone-black (400 pounds) yielded 168 bushels. Nitrate of soda (200 pounds) and sulphate of potash (300 pounds) gave 233 bushels per acre. Nitrate of soda (200 pounds), dissolved bone-black 400 pounds), sulphate of potash (300 pounds)—a complete fertilizer—gave 217 bushels. The Mapes potato manure (800 pounds, gave 257 bushels to the acre, while in the later experiments quoted by Mr. Harris, 1,200 pounds of the Mapes (3.70 nitrogen guaranteed) gave a yield of 273 bushels to the acre.

From a glance at the experiments carried on during the season to which Mr. Harris alludes, it is admitted that nitrogen alone gave a

greater increase over the unmanured plots than either potash or phosphoric acid or both. It is just as evident, withal, that in no instance was a large crop raised except when a high-grade complete fertilizer was used. Whether a smaller quantity of the fertilizer and an additional dose of nitrogen would have given as large a crop we have no proof one way or the other. If we were striving to raise the largest possible yield per acre, we would not use nitrogen in the form of nitrate of soda alone, but in the blended forms of nitrate of soda, sulphate of ammonia, dried blood, urate of ammonia and other organic salts of ammonia found in Peruvian guano, all of them soluble, but in varying degrees. Moreover, we should supply them, especially on light and fallow land, in minimum quantities consistent with experience, on account of their expense and the liability of loss by leaching. It is easy to supplement nitrogen to a growing crop by top-dressing, if it is thought that it will prove serviceable, as, especially in the form of nitrate, it is exceedingly prompt in its action. On a portion of the same impoverished field upon which the potato trials alluded to were made, the effects of a dressing of 150 lbs. to the acre of nitrate of soda on corn were plainly visible 50 feet away, three days after the application, in the darker color of the leaves as compared with the rest of the field which had received potash and phosphoric acid only.

Our great authority, Sir J. B. Lawes, grew potatoes on the same plots for nine consecutive years, from 1876 to 1884 inclusive. The average yield from the use of 400 lbs. of ammonia salts alone was 103 bushels per acre ; that from 550 lbs. of nitrate of soda was 104 bushels. The same amount of ammonia salts, with the ash elements added (complete), produced an average for the nine years of 325 bushels per acre. Nitrate of soda (550 lbs.), with the ash elements added, gave 300 bushels per acre. Farm-yard manure (16 tons)—an average of six years—gave a yield of 253 bushels per acre.

Mr. Harris remarks that the 200 lbs. of nitrate of soda used in several of my experiments to form complete fertilizers, can be bought for $5. We agree with him that for potatoes it is an ill-balanced fertilizer in most cases, not, however, because it contains too little nitrogen necessarily, but because it does not exist in varied forms and also because the potash is too low by half for soils deficient in potash. Where a large crop is anticipated it is always safer to use an excess

of food constituents, particularly of those that do not waste by leaching. Phosphoric acid is, next to nitrogen, the ingredient oftenest deficient in soils. Nine-tenths of the fertilizers used in England and America are mainly phosphoric acid. Potash in many soils, however, is present in liberal quantities, and it would be unwise to supply it in full rations unless a known deficit exists.

If you err at all, gardeners and farmers, it is better to err on the side of economy. Phosphoric acid will remain with you to feed subsequent crops. So will potash. Know that your soil needs more nitrogen before you apply it in liberal doses. Nitrogen costs a lot of money, and the higher the price of experiment ingredients, the less the farmer should apply it without due discrimination. We say give the soil all the phosphoric acid you choose. You will rarely overdo it. Give it potash according to its needs, as nearly as you may. But be gentle and conservative in the use of nitrogen, unless you are positive it will give you full returns. It is a ruinous luxury.

We may every one of us bear in mind that if phosphates materially increase our crops, we have evidence, to a certain extent, that nitrates are the less needed at present; if potash increase the crop, here is evidence that nitrates are the less needed. If both phosphates and potash fail, then let the experimenter add nitrates in varying quantities from 100 to 300 pounds to the acre, and thus in a safe, inexpensive way find out approximately what his land needs.

THE EFFECT OF NITROGEN IN VARYING QUANTITIES UPON POTATOES—EFFECTS OF INCREASING QUANTITIES OF FERTILIZERS.

This question of how much nitrogen farmers or gardeners may with profit give to the soil is one manifestly of the first importance. Mr. Harris's position may be repeated and emphasized in the following words: "It is a matter of surprise that Mr. Carman does not see that his own experiments demonstrate that, so far as the production of potatoes is concerned, his worn-out soil was more deficient in nitrogen than in any other constituent of plant-food."

It was to throw more light upon this question that the following trials were made during the past season (1890). Mr. Harris contends that the chemical fertilizers of to-day, as a rule, contain too small a quantity of nitrogen; that the minerals (potash and phos-

phate) are the strong links, and that a deficiency of nitrogen is the weak link of the chain by which the crop, in due proportion, will be diminished. An injudicious advocacy of the good effects to be derived from nitrate of soda, on the part of many writers, has had a decided effect upon those who have not studied chemical fertilizer problems to induce them to jump at the conclusion that it will insure a profitable increase of crops regardless of the needs of the soil. Nitrogen (it may well be repeated) is neither more nor less valuable to the farmer or gardener than is either potash or phosphate. It is far more costly and, while the phosphate and potash remain in the soil for subsequent crops if not used up by the current crop, nitrate of soda, unless supplied in repeated doses, often fails to carry a late crop through to maturity.

The plots (23 in number) were planted April 26, by the trench method, so often described. The variety was the Rural Blush, the fertilizer was the Mapes, with the following analysis :

Ammonia	4.50 to 5	per cent.
Phosphoric acid	8 to 10	"
Potash	6 to 8	"

		Bushels per acre.
Plot 1.	No fertilizer of any kind	207.50
" 2.	440 lbs. potato fertilizer to the acre	214.50
" 3.	440 " " " " and 55 " to the acre of nitrate of soda	249.33
" 4.	440 " potato fertilizer and 110 " nitrate of soda	249.33
" 5.	440 " potato fertilizer and 220 " nitrate of soda	284.17
" 6.	440 " potato fertilizer and 330 " nitrate of soda	309.83

In the above experiment it is plain that the yield increases (with one exception, when they are the same) as the quantity of nitrate of soda increases. It must be borne in mind that but 440 pounds to the acre of the potato fertilizer was used in any one of the above six trials.

			Bushels per acre.
Plot 7.		No fertilizer of any kind	260.
" 8.	880 lbs. / 55 "	potato fertilizer and nitrate of soda	297.
" 9.	880 " / 110 "	potato fertilizer and nitrate of soda	315.
" 10.	880 " / 220 "	potato fertilizer and nitrate of soda	368.50
" 11.	880 " / 330 "	potato fertilizer and nitrate of soda	308.
" 12.	880 "	potato fertilizer without any nitrate of soda	315.

Here it would appear that there are indications that the larger amount of potato fertilizer gave the crop nearly all the nitrogen needed, since 880 lbs., without additional nitrate, gave as large a yield (315 bushels) as did the addition of 110 lbs. of nitrate of soda, as in plot 9. It is true that plot 10, with 220 lbs. of nitrate, gives the heaviest yield, offset by the yield of plot 11, which received 330 lbs., yielding but 308 bushels.

			Bushels per acre.
Plot 13.	1,320 lbs.	potato fertilizer, no nitrate of soda	344.60
" 14.	1,320 " / 55 "	potato fertilizer and nitrate of soda	403.33
" 15.	1,320 " / 110 "	potato fertilizer and nitrate of soda	375.83
" 16.	1,320 " / 220 "	potato fertilizer and nitrate of soda	396.
" 17.	1,320 " / 330 "	potato fertilizer and nitrate of soda	353.83

The above results, as will be seen, are contradictory. It is evident that 1,320 lbs. of the potato fertilizer should furnish, of itself, all the nitrogen which the crop could use. Nevertheless, an addition of 55 lbs. to the acre of nitrate of soda gives the largest yield of any. Larger quantities seem to reduce the yield more or less, though the addition of 220 lbs. gives the next heaviest yield.

On a different part of the field, where the land is a trifle lighter and apparently more uniform, nitrate of soda in varying quantities was used without any potato fertilizer. The following are the results:

			Bushels per acre.
Plot	18.	55 lbs. of nitrate of soda	403.33
"	19.	110 " " "	302.50
"	20.	220 " " "	352.
"	21.	330 " " "	315.

Here it will be seen that the small amount of 55 lbs. to the acre of nitrate of soda, without any potato fertilizer, gave as large a yield as plot 14, which received the same amount of nitrate of soda and 1,320 lbs. of the potato fertilizer.

In the two following experiments a fertilizer high in ammonia, 7.50 per cent; high also in potash, 10.50 per cent, but low in phosphoric acid, 4.50 per cent., was tried. The results were as follows:

			Bushels per acre.
Plot	1.	440 lbs. to the acre	279.
"	2.	880 " " "	330.

SUMMARY.

We may summarize in this way:

Average of plots that did not receive either potato fertilizer or nitrate of soda alone, 233.75 bushels to the acre.

With 440 lbs. of potato fertilizer, nitrate of soda, from 55 to 330 lbs. to the acre, increased the yield over the no-fertilizer plots 39.41 bushels per acre.

With 880 lbs. of potato fertilizer, nitrate of soda, from 55 to 330 lbs. to the acre, increased the yield over the no-fertilizer plots 87.50 bushels per acre, or but 6.25 bushels over the plot which received the same amount of potato fertilizer (880 lbs.) without nitrate of soda.

With 1,320 lbs. of fertilizer, nitrate of soda from 55 to 330 lbs. to the acre, increased the yield over the no-fertilizer plots 148.50 bushels to the acre, or 35.65 bushels over the plot which received the 1,320 lbs. of fertilizer alone.

The results of the above experiments would seem, though in a feeble way, to justify Mr. Harris's conclusions that the potato fertilizers of to-day are too low in nitrogen. Still we would as urgently as ever advise farmers not to depend upon nitrogen for a profitable increase of crops, but rather to see to it that the land is well supplied

with minerals, and to experiment with the costly nitrogen, using on different portions of the same field, as we have done, all the way from 55 to 320 lbs. to the acre—an experiment which, conducted on small plots, involves neither much trouble nor expense. Remember that what you do not recover of nitrate of soda or sulphate of ammonia in the crops of the season, you will never recover. But the phosphates and potash that one crop may not use will remain for the next.

CHAPTER XII.

Sundry Experiments.

POTATO CULTURE IN HALF-BARRELS.

CEMENT barrels were sawed through the centre and the half-barrels, or kegs, used. Beauty of Hebron Potatoes, of equal weight, were selected for seed and cut in halves, the seed-end-half alone being used. They were planted in the morning of April 10.

No. 1. Pure Sand.—Seed piece planted six inches deep. This keg (half-barrel) gave the strongest, tallest plants, and the leaves were the darkest color of any. July 18, the tops being dead, the barrel was broken apart, leaving the sand the shape of the barrel so that the tubers and roots could be carefully examined. The roots penetrated to every portion of the sand. The box was watered with horse-manure water, and small quantities of nitrate of soda, dissolved bone and potash were sprinkled upon the surface of the sand and scratched in. The tubers of the yield weighed 45½ ounces. They were 35 in number, of the average size of hens' eggs and uniformly so. Eight of the best weighed one pound. All were clean, bright and smooth. The seed piece was so decayed that little but the skin remained.

No. 2. Garden Soil.—Seed piece planted four inches deep. Watered as often as needed with rain water. Yield, 40 ounces. There were 43 tubers, one larger than in No. 1. Eight of the best weighed 12 ounces. Tubers not so shapely or smooth. Roots penetrated to every part of the soil. Seed piece quite decayed.

No. 3. Three-Quarters Garden Soil, One-Quarter Sand.—The seed piece was placed upon the soil and covered with the sand. Watered

with rain water. The yield was 21 ounces, 38 tubers. The best eight weighed 10½ ounces. Clean and shapely, as in No. 1. Seed piece decayed.

No. 4. Three-Quarters Garden Soil, One-Quarter Cut Straw.—The seed piece was placed upon the soil and the half-barrel filled with the straw. Watered with rain water. The yield was 11 ounces. Twenty clean, shapely tubers formed almost in a ball about the seed piece, which still retained its form plump and solid, and was still pushing new buds. Upon cutting it open, the flesh was watery and semi-translucent, as if exhausted of starch. This seed piece which, as above stated, was the seed-end-half of Beauty of Hebron, was cut in two and each piece again planted in the garden, but the sprouts, if indeed any grew, did not appear above the soil. The roots of this barrel penetrated to every portion of both the soil and straw.

THE THREE BARRELS.

On April 10th, 1889, three barrels of the same size were provided with perfect drainage, and filled to within 16 inches of the top with garden loam and sand—half and half—thoroughly mixed. While mixing the sand and loam together, potato fertilizer was added—one quarter of a pound to each barrel. In the first barrel a single tuber (medium size) of seedling No. 2 was placed upon the loam and sand, being 16 inches below the top of the barrel. In the second barrel a single tuber of the same size, of seedling No. 3 was similarly placed. A single tuber of the seedling No. 4, of the same size, was placed in the third barrel. These potatoes were then covered with about three inches of the same sand, loam and fertilizer, the distance from the top of the soil being now about 13 inches. As the shoots of the growing potatoes appeared above the surface, more soil and sand were added, until the barrels were filled to within an inch of the top, and the tops were then allowed to grow as they would, being at length supported by a platform raised to the height of the barrels. The seed was planted April 10, and the shoots of all three appeared above the soil May 18, there being scarcely ten hours difference.

Planted 16 inches deep, where would the tubers form ; near the bottom, midway, or in tiers from the bottom to the top ? This is what the experiment was designed to show. It was also designed to show

the root and tuber-forming growth of plants raised under these peculiar conditions. The plants were watered as water was needed. It was not necessary to apply poison, as the potato beetles seemed to prefer a lower plane. In the earlier part of the season the leaves showed no flea-beetle perforations, and few were seen upon them. Later they injured the leaves as much as those growing in the plots near by. This is noted because it has been stated that the cucumber flea-beetle confines itself to within a foot or so of the ground.

It was the design to have sawed the barrels lengthwise, in halves, and to have removed the soil and sand just as the vines began to show maturity, but while yet the potatoes would cling to the stems. Thus the root and tuber-bearing systems could have been well shown after the sand and soil had been carefully washed out by the use of a hand-pump and hose. The vines "blighted," however, in mid-July and were quite dry and dead before the services of a photographer could be secured.

The cut shows fairly well in what part of the barrel the tubers grew, apparently from 4 to 12 inches below the surface, yet while washing out the sand and soil, several fell from their places. The reader must bear in mind that back of those shown in the illustration, other potatoes were covered and concealed in the sand and soil. The yield was as follows:

No. 2 yielded 13 marketable potatoes, 8 small and 2 rotten, weighing six pounds. The decayed tubers were not weighed or taken in the account. Allowing three square feet to the hill, as in field culture, the yield would be 1,452 bushels to the acre.

No. 3 blighted earlier than the others and the yield was 20 very small potatoes weighing 14 ounces.

No. 4 yielded 13 marketable and 3 small tubers. Not less than ten were rotten and not estimated. They weighed 4½ pounds.

SEED PIECES VARIOUSLY TREATED.

Test No. 26. Queen of the Valley was cut to two-eye pieces and placed in a spade-wide furrow, or trench, four inches deep in mellow garden soil. They were then covered lightly with soil and the furrow nearly covered with straw. On this, chemical potato fertilizer was thrown at the rate of 500 pounds to the acre, and the furrow was then

leveled with soil. The yield was 907.50 bushels to the acre. Best five weighed six and one-quarter pounds. Large and small, 135,520 to the acre, or 9⅓ tubers to the hill.

Test No. 27. Same variety, planted in the same way as in No. 26. The pieces were covered lightly with soil, then with a liberal spread of hen manure, which was covered lightly with soil; then a second spread of hen manure, and finally the furrow was filled with soil. The yield was at the rate of 705.83 bushels to the acre. Best five, four pounds one ounce. Large and small, 116,160 to the acre.

Test No. 28. Planted as above, and a heavy spread of salt—40 bushels to the acre—strewn over the pieces, which were first lightly covered with soil. The seed pieces rotted in the ground.

Test No. 30. These were manured with chemical fertilizers at the rate of 1,000 pounds to the acre without straw mulch. The yield was 665.50 bushels to the acre. Best five, five pounds. Large and small, 101,640 to the acre, or seven potatoes to the hill.

Test No. 31. These pieces (Peerless, as in Nos. 29 and 30) were covered lightly with soil, and the trench filled with stable manure (the same as No. 26 was filled with cut straw). No fertilizer was used. The yield was 907.25 bushels to the acre. Best five weighed three pounds eight and one-half ounces. Large and small, 217,800 to the acre, or an average of 15 to the hill. This yield was about the same as in No. 26, but the potatoes were smaller and much injured by wire-worms.

Test No. 32. These pieces (Peerless) were first covered with soil lightly, then salt at the rate of 15 bushels to the acre, then a mulch of stable manure as in No. 31; then a spread of hen manure, at the rate of 20 bushels to the acre, and finally unleached ashes at the rate of 15 bushels to the acre. The object of this trial was to ascertain, first, whether a surfeit of manure would increase the yield, and second, whether the salt would have any effect to keep wire-worms away, as compared with No. 31, which received only stable manure. The yield was 826.83 bushels to the acre. Best five, five pounds. Large and small, 179,080 to the acre, or 12⅓ to the hill. They were eaten as badly as in test No. 31.

A NEW WAY TO MULCH POTATOES—VALLEY MULCHING.

Mulching potatoes is sometimes very successful, and at other times useless, or harmful. The effect depends upon the soil or season. When the early spring is backward and wet, the mulch keeps the soil cold; the seed pieces are delayed in sprouting and an imperfect stand is the result. What is wanted is a mulch that will conserve moisture and yet not intercept the warming rays of the sun. The "valley" system it was thought might accomplish this. Whether it is practicable or profitable, we are not prepared to say.

The soil (an impoverished, sandy loam) was plowed, raked and leveled the same as if grass seed were to be sown, as shown by line *a*, Figure 2. The seed pieces (two eyes) were then placed on the soil one foot apart in rows three feet apart, as shown at *b*. These pieces were then lightly covered with soil hoed from between the rows (1, 2, 3,) and at the

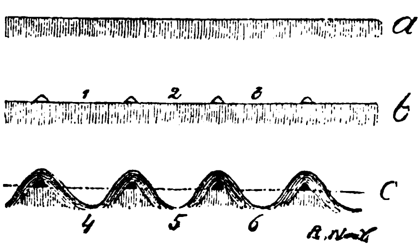


FIG. 2.

rate of 1,000 pounds per acre of Baker's potato fertilizer strewn evenly over it. Then more soil was hoed over the fertilizer until continuous hills five inches high were formed, as shown at *c*, forming the valleys, as shown at 4, 5, 6. The valleys were then filled with a mulch of coarse straw and hay that had been raked up into cocks from a part of the field where it had lain all winter, thus partly filling the valleys, as shown by the dotted line. The design was that such plots were not to be cultivated during the whole season. If the mulching material is old, few seeds will sprout in the mulch, while those that sprout beneath it will be smothered. The weeds that grow on top of the hills may be pulled up. But the vines very soon cover the hills, forming a shade not favorable to their growth. The yield of potatoes was 45 pounds, which was at the rate of 352 bushels to the acre, 60 per cent. of which were marketable as to size.

If it were desirable to try this system on a large scale, a small plow run both ways, or a shovel plow, would serve to turn furrows over the pieces, leaving the valleys to be mulched. In the

SECOND EXPERIMENT,

which is by no means new, the pieces were placed on the top of the leveled soil as before, and the same kind of mulch spread over them five inches high directly over the pieces and sloping gradually towards the other rows. Upon this mulch the same quantity of the same fertilizer was sown. The yield was at the rate of 330 bushels to the acre. In this trial there were 316 tubers (45 pounds), of which 162 were of marketable size. Many, however, were injured by grubs of the May beetle and wire-worm. The next test was the trench-mulch system, using the same quantity of the same fertilizer. The yield was 316 potatoes (31¾ pounds) of which 156 were marketable. This was at the rate of 276.83 bushels to the acre.

Another trench without mulch, and fertilized with the same manure, at the rate of 1,200 pounds to the acre, yielded at the rate of 278.66 bushels, there being 314 tubers (38 pounds), 146 marketable.

The fertility of the soil is shown approximately by the yield of two trenches that were not fertilized. The first yielded 162 potatoes (12¼ pounds) of which 54 were of marketable size, though very scabby. This is at the rate of but 91.66 bushels to the acre. The second unfertilized trench yielded 156 tubers (15½ pounds) of which 60 were marketable as to size, but much injured by scab. This is at the rate of 113.66 bushels to the acre.

The average yield of the unmanured trenches was 102.66 bushels to the acre. The trench (not mulched) which received 1,200 pounds of fertilizer yielded at the rate of 278.66, an increase over the unfertilized trenches of 176 bushels. The trench which was mulched (trench-mulch plan) and given 1,000 pounds of fertilizer gave an increase over unmanured plots of 174.18 bushels ; the surface mulching an increase of 228.66 bushels, and the "valley" mulching an increase of 250.66 bushels to the acre.

The philosophy of the method seems sensible enough. About a foot of soil in width directly over the pieces is without any mulch, and the mellow, loose soil receives the air, the sun's rays and the rain, while the mulch in the valleys should assist in retaining the moisture so received for the benefit of the roots until the growth of the tops covers all.

DOUBTS EXPRESSED AS TO REPORTED YIELDS.

When in 1882, I reported that several of the potatoes tested yielded at the rate of over 700 bushels per acre, several friends, as previously intimated, wrote that they doubted the fact. One said that he had raised potatoes all his life, and that he considered himself a good farmer, yet he had never harvested 400 bushels from an acre. Were we to judge alone from my farm experience in the sandy soil of my Long Island (N. Y.) farm, I should be ready to share the doubts of this correspondent. There we have never raised a large crop of potatoes, though we have tried over 100 different kinds, and raised them under different methods of cultivation, and with different manures. Later, as previous mention has been made, we were both surprised and pleased at the quantity of potatoes, which, it was found, could be raised upon our New Jersey experiment plots. Many trials have proved utter or partial failures, as was to have been expected; still in many cases we have harvested at the rate of over 700 bushels to the acre; in quite a number over 800 bushels; in six or eight cases over 900; in three over 1,000; in one case over 1,100 bushels, and finally, in another over 1,800.

METHOD OF COMPUTING YIELDS.

The method of computing yields is a simple and, as will be seen, an entirely accurate one. The only way in which it differs from field yields, is that every hill is counted. There is no allowance made for vacant hills, which always occur upon large areas. That is to say, if we plant 20 pieces and but 10 grow, we estimate the yield by 10 hills—not by 20. As a rule, however, every piece planted grows, so that generally there are no changes to be made. Upon 10 acres of the *same* land, *manured*, *planted* and *cultivated* in the *same* way and to the *same variety* of potato, we should of course look for essentially the same yield.

The method of computing the yield is as follows: The pieces are always placed by measure just one foot apart in drills three feet apart. A cord with knots in which short strings are tied one foot apart, is stretched over each drill its entire length. The seed pieces are placed under these marks. With pieces placed one foot apart in drills three feet apart, we should have 14,520 pieces to the acre.

Now if we plant 20 pieces, and the yield is 50 pounds, the rule of three will give the yield per acre in pounds. This must be divided by 60, the legal number of pounds for a bushel of potatoes, and the answer gives the yield per acre, viz., 605 bushels. The yield is weighed upon nicely balanced scales placed near the plots, and each kind is weighed as soon as harvested, and the weight, even to the quarter of an ounce, and the number of potatoes, large and small, are recorded at once. In ordinary experiments of this kind, aliquot parts of an acre are desirable for easy computation.

THE BEST DISTANCE APART FOR SINGLE EYES.

The following experiments were made in 1881 to ascertain what distance apart potato "seeds," cut to single eyes, should be planted in order to produce the best yield of *marketable* potatoes. Each test row was but 33 feet in length; the variety planted was Beauty of Hebron. An old sod was plowed under in the winter of 1880. The land was well prepared the following spring. The seed pieces were placed in shallow furrows, three feet apart, May 18, and upon them a slight sprinkling of concentrated potato fertilizer was strewn. The soil was then hoed back so that the entire plot was quite level. The same fertilizer at the rate of 300 pounds per acre was afterwards spread broadcast, just previous to the first cultivation.

That the yield was light in every case was no doubt due to the fact that the season was unfavorable to the potato crop, being very dry in the early, and too wet in the later part.

ONE EYE IN A PLACE—ALL THE DRILLS 33 FEET IN LENGTH.

18 pieces, weighing 12 ounces. Yield 24 pounds.
(18 pieces in a drill 33 feet long would be 22 inches apart.)
20 pieces, weighing 14 ounces. Yield 14½ pounds.
(This row was harmed by moles.)

25	pieces,	weighing	14	ounces.	Yield	25½	pounds.
28	"	"	14½	"	"	26¼	"
30	"	"	18	"	"	21	"
33	"	"	22	"	"	24	"
40	"	"	23	"	"	20	"
49	"	"	26	"	"	28¼	"
66	"	"	32	"	"	31¼	"

TWO PIECES, EACH HAVING BUT ONE EYE, PUT CLOSE TOGETHER IN DRILLS 33 FEET IN LENGTH.

40 pieces, weighing 22 ounces. (Nearly 10 inches apart.)	Yield 24½ pounds
50 pieces, weighing 24 ounces.	Yield 27 "
60 pieces, weighing 28 ounces.	Yield 24½ "
66 pieces, weighing 34 ounces.	Yield 25¼ "

THREE PIECES (SINGLE EYES) PUT CLOSE TOGETHER IN DRILLS 33 FEET IN LENGTH.

48 pieces, weighing 22 ounces. (Injured by moles.)	Yield 18 pounds.
75 pieces, weighing 40 ounces.	Yield 24 "
90 pieces, weighing 42 ounces.	Yield 24 "

The average size of the last was much smaller than any of the others.

FOUR PIECES PUT CLOSE TOGETHER IN DRILLS 33 FEET LONG.

64 pieces, weighing 33 ounces. Yield 24 pounds.

FIVE PIECES CLOSE TOGETHER—DRILL 33 FEET.

80 pieces, weighing 36 ounces. Yield 27 ounces.

On comparing the various products (but omitting such as were injured by moles), it appears that in the two poorest rows the average number of pieces was 35, and the average product 20½ pounds, making the yield per acre equivalent to 150 bushels. It will also be seen that in the best row the number of pieces was 66, with a yield of 31¼ pounds, making the rate per acre 225 bushels. Taking the average rate per acre for all the rows together, we find it equal to 184 bushels, with 50 pieces in each row, and for the five best rows 209 bushels per acre, with an average of 64 pieces per row.

Now to show in what way, and to what extent the spaces in planting affect the yield, we have the following figures :

	Bushels per acre.
35 pieces per row represent a yield of about	159
50 " " " " "	184
64 " " " " "	209
66 " " " " "	225

IN OTHER WORDS,

The distance apart for	150	bushels	per acre	was nearly	12 inches.
" " " "	184	"	"	"	8 "
" " " "	209	"	"	"	7 "
" " " "	225	"	"	was just	6 "

In another view also, this result is further confirmed, for if we take the closest planting above given (which is six inches in the row), it shows an area of 216 square inches for each single eye, which is space enough for a much larger yield than either of the above.

TESTS WITH DIFFERENT NUMBERS OF EYES TO A PIECE.

No. 83v. Variety planted, the Improved Peachblow. Single strong eyes, one by three feet apart. Yield, 171.45 bushels per acre. Large and small, 33,880—a very large average size. No small potatoes. Best five, 2 pounds 11½ ounces.

No. 84v. Two strong eyes in one piece. Yield, 252 bushels per acre. Large and small, 50,820 to the acre. Best five, 2 pounds 8½ ounces.

No. 85v. Three strong eyes to a piece. Yield, 292.50 bushels per acre. Large and small, 50,810 to the acre. Best five weighed 2 pounds 13½ ounces.

No. 86v. Four strong eyes to a piece. Yield, 322.66 bushels per acre. Large and small, 62,920. Best five weighed 3 pounds 3½ ounces.

Single strong eyes of White Star gave a yield at the rate of 171.45 bushels; two strong eyes, 252 bushels; three strong eyes, 282.50; four strong eyes, 322.86.

DIFFERENT SIZED PIECES WITHOUT REGARD TO NUMBER OF EYES.

Trench No. 1. Rather small potatoes were cut into four pieces. Yield per acre, 230.41 bushels. There were 193 marketable potatoes and 56 small. The vines were rated June 27, as six, 10 being best.

Trench No. 2. Half potatoes were used in this trench. The yield per acre was at the rate of 256.66 bushels. There were 165 marketable—282 very small, none very large. The vines were rated June 27, as six.

Trench No. 3. Whole Potatoes.—The yield per acre was at the rate of 278.66 bushels, of which 236 were marketable and 310 small.

It will be seen that whole seed gave 48 bushels per acre more than quarter pieces and 22 bushels more than half pieces. But the number of unmarketable potatoes increased with the size of the seed—the whole pieces giving the greatest number, the half pieces next and the quarter pieces fewest.

POTATO SKINS CUT TO SINGLE EYES.

May 26th were planted in well prepared ground, 37 pieces of potato skins—each having a single strong eye—six inches apart in the drill. The 37 pieces weighed two ounces. Three grew, and the yield was half a dozen potatoes as large as marbles. The experiment was made to test the value of a positive assertion on the part of a "well known" farm writer that such eyes would yield as well as those to which flesh is attached.

EXPERIMENT TO DETERMINE HOW MUCH FLESH EACH EYE SHOULD HAVE WHEN PLANTED TO PRODUCE THE MOST PROFITABLE CROP.

Test 46 A. The seed potatoes were selected all of the same size, and peeled, all eyes being cut off except the strongest near the middle—that is, whole potatoes were peeled so that but one eye was left with a ring of skin about it. It would be equivalent to cutting out all the eyes but one, and then planting the whole potato as if it were a seed piece with a single strong eye. The variety was the Peerless; the amount of chemical potato fertilizer used was 1,000 pounds to the acre. They were planted one piece (four inches deep) every foot in trenches (spade wide) three feet apart; cultivation flat. The yield was at the rate of 806.66 bushels to the acre. The best five weighed 3 pounds 3 ounces. There were of large and small potatoes at the rate of 140,560 to the acre, or 9⅔ to a hill.

Test 47 A. The pieces were cut as shown by figure 3, and of that size. They were planted, as in 46 A, three inches deep. So many of the pieces either failed to sprout, or died after the sprouting, that no estimate could be made of the yield per acre.

FIG. 3

Test 48 A. In this test cylindrical pieces were cut through the potato as shown at Fig. 4, with a strong eye upon one end, and planted four inches deep. The yield was at the rate of 211.75 bushels to the acre. Of large and small there were at the rate of 87,120 potatoes to the acre, or six to a hill.

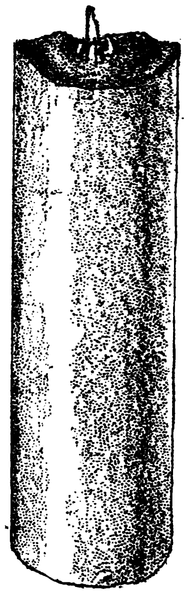


FIG. 4.

In order to ascertain how much flesh should be left to an eye or to the eyes of seed pieces, it would doubtless be necessary to repeat the tests hundreds of times in different soils, and with different varieties. "Enough is as good as a feast,' but what would be enough in a wet spring might prove too little in a dry one; what might serve in a rich soil might prove insufficient in a poor soil. The quantity of flesh which should go with each piece, is, theoretically, that which without unnecessary waste, will best support the eyes until, by the growth of the roots, support from the flesh is no longer required.

SEED END *VS.* STEM END IN A RICH SOIL.

The seed end of Early Rose yielded 710.82 bushels to the acre. Largest five weighed 2 pounds 9½ ounces. Large and small, 214,170 to the acre, or 14¾ to the hill. The shoots appeared before those of the stem-end seed, and the tops were nearly twice as large.

The stem end of Early Rose yielded at the rate of 620.10 bushels to the acre. Best five, 3 pounds 8½ ounces. Large and small, 170,610, or 11¾ to the hill.

The seed end of the Rural Blush yielded 282.33 bushels to the acre. Best five weighed 1 pound 6 ounces. Large and small, 116,120 to the acre, or 8 to a hill. The shoots appeared before those of the stem end. The stem end yielded 937.71 bushels to the acre. Best five, 2 pounds 5½ ounces. Large and small, 232,320 to the acre or 16 to a hill.

The seed end of the Queen of the Valley yielded 363 bushels to the acre. Best five weighed 2 pounds 15½ ounces. Large and small,

67,760 to the acre, or over 4½ to a hill. The shoots appeared before those of the stem end. The stem end of Queen of the Valley yielded 393.21 bushels to the acre. Best five, 4 pounds 1½ ounce. Large and small, 72,600 to the acre.

Judging from these tests alone, we should *select* the *stem* end of the Blush and Queen of the Valley, and seed end for the Early Rose, except that in the latter case the potatoes averaged smaller. The seed potatoes were cut in halves, one for the seed, the other for the stem end.

It would appear that with some varieties it is better to plant stem ends, and such tests should be made with every variety.

SHALL THE DISTANCE APART OF THE SEED PIECES PLANTED BE PROPORTIONATE TO THE SIZE OF THE SEED?

Mr. T. B. Terry, in commenting upon the experiments made by several stations, as well as by myself, which seemed to show that small (one or two-eye) pieces were not profitable, expressed the opinion that experimenters should plant small seed closer together, in order to make the conditions equal. We were, therefore, induced to resume our trials during the past season (1890), in the hope of throwing more light upon this really important problem. As a single experiment it is not worth much except as continued trials, season after season, in different land and with different varieties, may confirm the outcome, and give data for generalizations. All the potatoes used for seed were of medium size. It may be said that the tubers from the *whole* seed were smaller than those from any of the smaller seed. The record showing the comparative size was unfortunately lost.

This trial was made in an impoverished soil of a clay loam, fertilized with 1,000 lbs. to the acre of the Mapes potato fertilizer, of which an analysis has been given on previous pages. The pieces were placed in trenches four inches deep, and three feet apart measuring from the middle of each, on a plot of one-fortieth of an acre—33 feet square. It will be seen that we have on this plot 1,089 square feet, which divided by three gives 363 seed pieces, if planted one foot apart in the trenches.

No. 1. 132 pieces, single eyes, yielded at the rate of 187 bushels per acre. The pieces were placed three inches apart.

No. 2. 66 pieces, single eyes, yielded at the rate of 209 bushels to the acre. The pieces were placed six inches apart.

No. 3. 66 two-eye pieces, yielded at the rate of 227.33 bushels to the acre. The pieces were placed six inches apart.

No. 4. 33 half potatoes, yielded at the rate of 227.33 bushels to the acre, the same as plot No. 3. The half potatoes were placed one foot apart.

No. 5. 33 whole potatoes, yielded at the rate of 282.33 bushels to the acre. The tubers were placed one foot apart.

It appears, therefore, that whole potatoes of medium size, placed one foot apart, in trenches three feet apart, yielded over 95 bushels per acre more than single eye pieces placed three inches apart; 73 bushels more than single eye pieces placed six inches apart, and 55 bushels an acre more than either two-eye pieces or half potatoes.

CHAPTER XIII.

Size of Seed. Generalizations. Habit of the variety to be considered. Small seed of some kinds—Large of others. No positive rule can be given. Illustrations. The loss from missing hills. Underground development. Relations between few eyes and long joints. Bushy and "leggy" vines. True roots and tuber-bearing stems.

THE SIZE OF SEED.

FIG. 5 shows how potatoes usually sprout in a dark cellar when not in contact with other potatoes or with any damp substances. It will be seen that the buds ("eyes") of the "seed-end" have alone sprouted. We have found that in many varieties these are the only buds which do push, either in the cellar or *when planted*. The "eyes" of the other parts seem "blind" or impotent. The pieces rot in the ground. With other varieties every "eye" will sprout, though those of the "seed-end" are almost always the strongest and the first to sprout.

Hence it would appear that the size of the "seed" to be planted should be determined by the habit, so to speak, of the variety and not by any fixed rule to use one, two, three eyes, half or whole seed. Hence it is, too, that reports of experiments to settle this vexed question are so contradictory. We will guarantee that an experiment of this kind with my No. 2 Seedling would show that one-quarter of each tuber, including the "seed-end" would give a greater yield than three-quarters of the tuber *without* the "seed-end." And we are further confident that if the seed of this variety were cut in halves, one-half being "seed-end" the other "stem-end," the stem halves

would fail to sprout in about six cases out of seven. Again, if we were using Wall's Orange or any other similar variety having many and prominent eyes, we should reject the seed-end and cut the rest to two or three eyes, depending upon the size of the seed tubers.

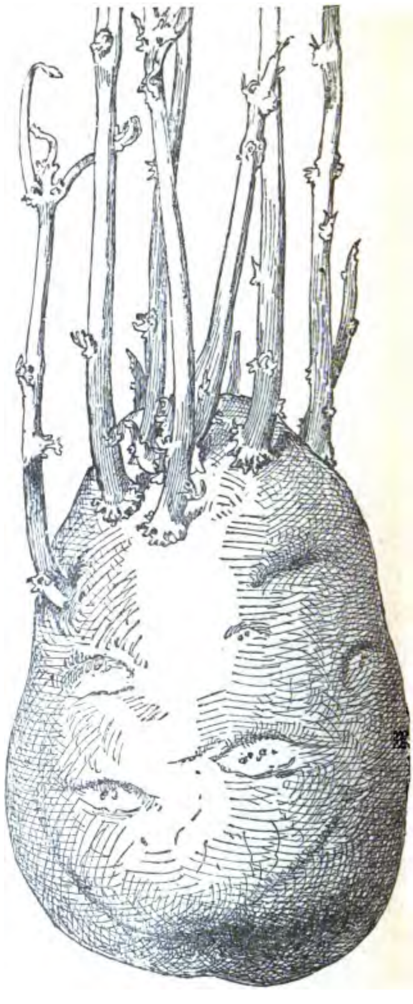


FIG. 5

The loss of the yield from "missing" hills is not well considered. In many a thrifty field of potatoes it is not uncommon to find 20 per cent. of missing hills. One-fifth of the crop is thus sacrificed; or if the actual yield be 200 bushels to the acre, the loss would be 50 bushels.

ABSURD NAMES.

Why call the ends of the potato "seed" and "stem" ends? These parts might better be called the top and bottom, since they are the top and bottom of a potato, the same as there is a top and bottom or an apex and base to a leaf, to a twig or a branch. We might even better say "butt" and "tip," as of the ear of corn. The seed-end of a potato is just as much the top of a potato as the topmost bud on a branch is the tip or top, and the stem end is the bottom or base, simply because it is the lowest portion. As in any

rooted cutting and as in most established plants, the top buds swell and grow first; so the "eyes" of the "seed" or the top of the potato push first.

POTATO GROWTH.

In my poor way I have studied during late years the underground development of the potato during its several stages from the sprouting of the seed piece to the development of the tubers, and would ask my readers' patience while I endeavor to explain it as best I may.

FIG. 6.

It seems that the distance between the joints of a potato *vine* (nodes) as well as the distance between the eyes, or nodes, or joints, of the underground shoot is proportionate to the *number of eyes on a potato*—their nearness together. That is to say, few-eyed potatoes will give a vine with fewer joints (longer internodes) than many-eyed potatoes. Supposing this to be true, one would infer that the fewer-eyed tuber would give the greatest length of vine and the least compact or bushy habit. A many-eyed potato would give closer-jointed stems and a greater proportionate amount of foliage. To a certain extent, therefore, the *number of eyes* of a given variety is a *guide* both to the *distance apart to plant* and *the depth to plant.*

The first true roots issue not from the seed potato in any case, but from *around* the eye or bud; from the growing shoot, which is the development of the eye or bud. These underground shoots make an effort to produce leaves at their nodes or joints which, being underground, die. From their axils the true fibrous roots grow which support the plant. From every node or joint, also, issue stems which at their ends *thicken* or may thicken into tubers. Above-ground leaves develop at the nodes or joints, and between them and the main stem (that is in the axil) secondary stems or branches grow. Underground, the *leaf* is *suppressed* and we have a leafless stem or slender shoot (provided with eyes or buds all the same) which at the tip or just behind it enlarges to form the tuber. The tip itself is a *suppressed leaf*, and the suppression seems to *induce* the swelling of the stem. Fig. 6 (p. 117) shows a seed potato which I lifted from a six-inch trench just before the sprouts had reached the surface soil. It will be seen that fibrous roots have grown from all the lower nodes of the shoots, and that the tuber-bearing nodes have not yet developed. Fig. 7 shows a potato taken from a barrel of potatoes in the cellar. The potatoes were moist and decaying, which gave the conditions essential for the growth of fibrous roots the same as if it were growing in the soil. Now if this condition of moisture and decay had not existed, the shoots would be like those of Figure 5, and they would continue to grow until the seed or parent tuber became exhausted of its nutriment. In

FIG. 7.

a lighter place leaves would grow from the nodes, but neither fibrous roots nor tuber-bearing stems would appear.

FIG. 8.
In the Hill. (Ideal.)

What we want is to provide those conditions economically that shall induce the greatest number of nodes to send out fibrous roots and tuber-bearing stems. In the usual system of raising potatoes, they are planted in V-shaped furrows scarcely three inches deep and covered; they are cultivated both ways and usually hilled up.

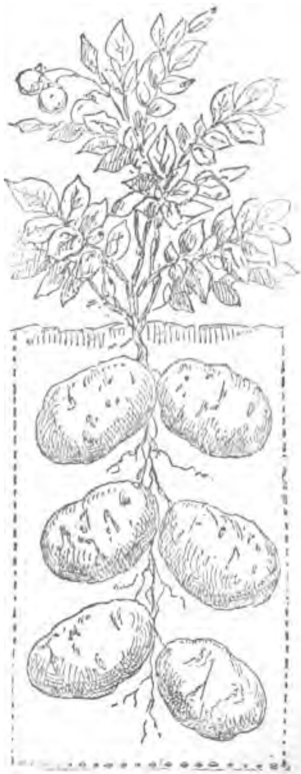


FIG. 9.
The Trench. (Ideal.)

We have tried to show that the sprout which is the growth of the "eye" changes into green leaves and vines above the ground in the air and sunlight, and that below it remains of a whitish color and sends forth roots and tuber-bearing stems. In the old method all the tubers must form in a comparatively narrow, cramped space. Between the seed-piece and the air there is but a length of perhaps three inches of stem—the portion which is to furnish the fibrous roots for the plant's support. There is, withal, only a single node or so, or several crowded together, and it is from these that the tuber-bearing stems issue. The plant may give a great amount of foliage, but it

cannot give a maximum amount of tubers, because the space for them to grow is too limited. In the trench the conditions are different. The seed-pieces are four, five, or even six, inches below the surface and three or four nodes, well separated, send out their fibrous roots and tuber-bearing stems. The root system is thrice as great. It is as if there were three or four tiers, or planes, for the growth of potatoes, a virtual extension of the area planted, the same as a ten-story house may occupy the same area of ground as a one-story house. Food is supplied in abundance. The roots grow deep and help to carry the plants through droughts. This they cannot so well do in shallower planting, being nearer the surface and more at the mercy of heat and droughts.

Fig. 10 (p. 121) shows a Thorburn (early) potato carefully lifted June 12; it was planted May 2. It will be seen that several tubers are beginning to form, while others are an inch or more in diameter. Some of the roots were thus early eighteen inches in length. In the old way these roots would have extended for the most part laterally on either side of the furrow or hill, having no mellow trench soil to go down into and spread out in all directions. In the trench the roots grow from the bottom as well as near the top. They prefer to go down, that being the easiest course; while there too they find the most food and moisture.

AGAIN, AS TO THE SIZE OF SEED-PIECES.

I beg to remark here that my experiments during the past fifteen years ought to throw some light upon the important question of the size of seed. As a result, my belief is that no one can say or will *ever be able to say*, whether it is better to use whole potatoes or any given number of eyes, or sizes of pieces, as a guide for all potatoes and different soils. The number of sprouts desirable to have in a hill depends to a great extent upon the distance apart of the hills, and upon the vigor of the vines.

Last year I dug up seed-pieces of different varieties planted ten days previously. Any one who will do this at such a time, will find that the size of the seed must be determined by the *number* and *vigor* of the eyes. For example, the R. N.-Y. No. 2 has not only few eyes, but those of the seed-end alone were pushing, notwithstanding the seed potatoes had been exposed to the light and heat for a week or

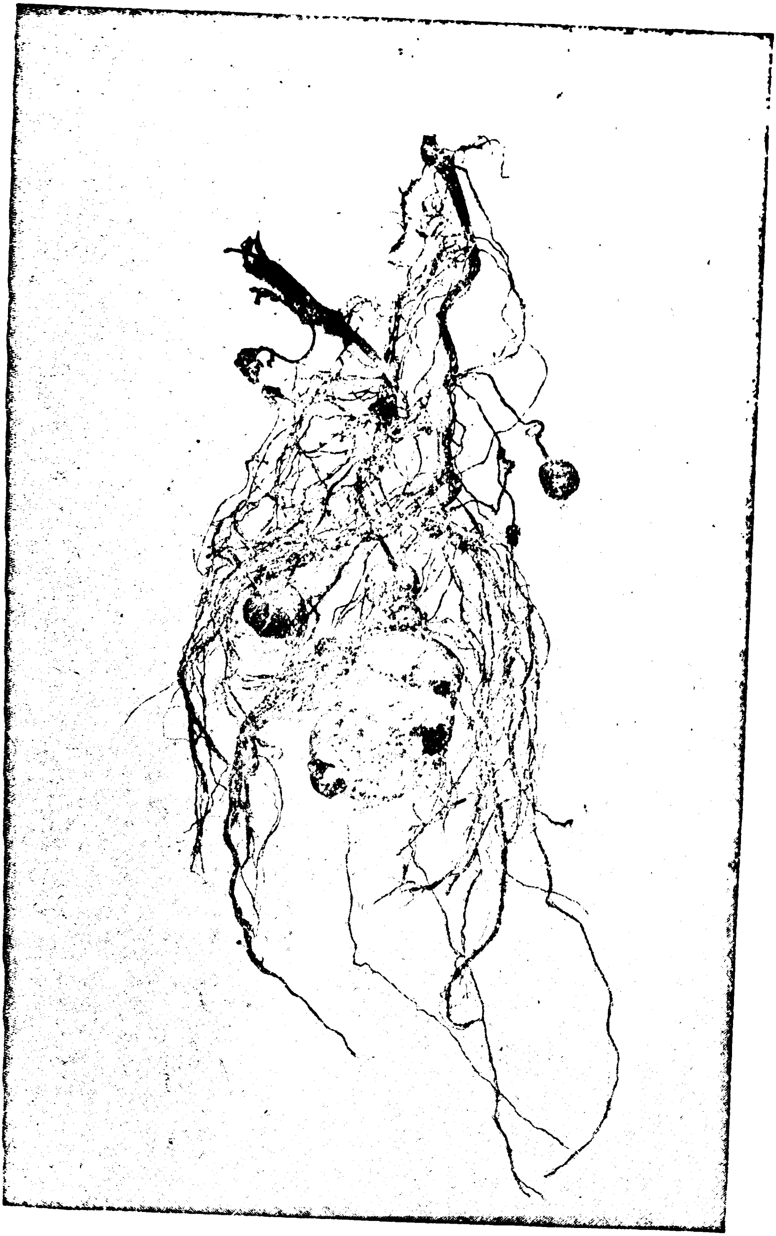


Fig. 10.

more before planting. Half pieces of this variety were planted. My No. 3 has also few eyes, yet from every eye planted a sprout was growing. Does it not follow that smaller pieces of the No. 3 than of the No. 2 should be planted? The Everitt potato has many eyes, and a peculiarity is that all seem equally sensitive or ready to grow.

Let us take 50 different varieties of potatoes—all of the same size—and cut them to two eyes. We shall find that some of the varieties will give a perfect stand, and yield a large crop of marketable potatoes, while others will give a very imperfect stand and a poor yield. The same will be the case if whole seed is planted. Some varieties will send up a dozen shoots, others only a few. The yield of the one may be a large crop of small potatoes; of the other, a large crop of large potatoes. The farmer can judge what sized seed to plant, when he sees and knows his potato, how the seed has been kept, and how it will act in his soil, and not until then—and there is no experiment station that can tell him.*

FIG. 11.

My experience has led me to answer all inquiries: "*Use large sized pieces containing two or three strong eyes*," and that is the nearest I can come to any fixed rule.

The advice to use "whole seed" is very bad indeed. I feel assured if followed out with certain varieties, a yield of small tubers will result every time, while with other varieties the advice may be as sound as a silver dollar.

The results at certain experiment stations, as well as my own, which show that the best yields come from whole seeds, prove simply that seed of some varieties, preserved in a certain way, and planted in a certain soil and situation, will give the largest crops for the particular varieties tried, and they prove nothing more.

*Varieties of potatoes which grow so closely together that they may be thrown out with one turn of the fork have, and necessarily so, short tuber-bearing stems. In varieties like The Rural Blush, that "straggle," the stem is long. This is shown at Fig. 11. The stem if straightened out would be a foot in length.

CHAPTER XIV.

Analysis of the tubers and vines. The effects of special or single fertilizers and in various combinations. The effects of "Complete" fertilizers. Stimulants. Complete fertilizers not necessarily effective. A familiar talk with farmers.

The result of 70 analyses of the tuber, by various chemists, embracing a great many varieties and modes of culture, are summed up in the following table :

	Minimum.	*Maximum.*	*Average.*
Water	68.29	82.88	75.77
Nitrogenous substance	0.50	3.60	1.70
Crude fat	0.05	0.80	0.18
Non-nitrogenous extractive substances, starch, sugar, etc.	12.05	26.57	20.56
Fiber	0.27	1.40	0.75
Ash	0.42	1.46	0.97

As the result of 53 analyses of the *ash* of the tuber, we have the following :

	Minimum.	*Maximum.*	*Average.*
Potash	43.97	73.61	60.37
Soda	0.00	16.93	2.62
Lime	0.51	6.23	2.57
Magnesia	1.32	13.58	4.69
Ferric oxide	0.04	7.18	1.18
Phosphoric acid	8.39	27.14	17.35
Sulphuric acid	0.44	14.89	6.49
Silica	0.00	8.LL	2.17
Chlorine	0.85	10.75	3.11

Six analyses of the *tops* give the following average results: Potash, 21.78; soda, 2.31; lime, 32.65; magnesia, 16.51; ferric oxide, 2.86; phosphoric acid, 7.89; sulphuric acid, 6.32; silica, 4.32; chlorine, 5.78. Potash and phosphoric acid are therefore predominating ingredients of the ash of the tuber, and soda and silica are evidently quite unessential, since they may be entirely absent; soda may also be wanting in the tops.

From these figures it may be estimated that in a crop of 150 bushels, weighing 9,000 pounds, and 600 pounds of tops, we should remove, of the three most valuable ingredients of plant-food, the quantities per acre given in the following table, omitting fractions. For the purpose of comparison, we give also the quantities of these three substances gathered by a crop of wheat, 25 bushels, and straw, 2,500 pounds; and of Indian corn, 50 bushels, stover 4,500 pounds, and cobs, 60 pounds.

		Nitrogen.	*Phos. Acid.*	*Potash.*
Potatoes:	Tubers	26	15	53
	Tops		4	11
	Total	26	19	64
Wheat:	Grain	30	13	8
	Straw	12	6	17
	Total	42	19	25
Indian corn:	Grain	48	20	12
	Stover	22	23	41
	Cobs	2		4
	Total	72	43	57

From these figures it appears that to produce the potato crop, potash is required in larger proportion than either nitrogen or phosphoric acid, and that more is required for this crop than for either wheat or corn, notwithstanding that the latter is such a gross feeder. When we come to consider the comparative exhaustion of the soil by the two crops, remembering that of the corn crop, only the grain with 12 pounds of potash is liable to leave the farm, while of the potato crop the tubers, with 53 pounds of potash for every acre, are usually exported, the usefulness of potash manures in potato culture would appear to be very plainly indicated. To the quantity of nitrogen

gathered by the potato crop, as given in the table, something must be added for the tops, with reference to which we find no determinations of this element. Making due allowance for this, the best manure for the potato would seem to be a "complete" one; that is, one containing all three of these substances—nitrogen, phosphoric acid and potash, with a large proportion of the last.

I have for years endeavored to call attention to the fact that many of the experiments made by farmers, and even by the officers of agricultural experiment stations, for the purpose of finding out what fertilizer constituents their land most needs, are delusive. If a given piece of land needs potash and nothing else, then that piece of land, year after year, will not yield maximum crops without potash. If it happens to need phosphates only, then full crops cannot be raised without some fertilizer which furnishes available phosphoric acid, as bone, fish, etc. If it stands in need of nitrogen only, nitrogen must be used. Here we have a plain case. The one ingredient needed is supplied in either trial and the land responds by giving the fullest crops of which it is capable. Each of the three farmers may truly say, "my land needs potash"—"mine phosphate"—"mine nitrogen." But suppose in the first example phosphate is needed as well as potash; in the second potash is needed as well as phosphate; in the third either is needed as well as nitrogen, what will probably be the result of the experiments? That the first piece of land will not give an increase of crop from the use of potash; the second will make little or no response to the phosphate, and the third none from the nitrogen. The experimenters jump at the conclusion that their land does not stand in need of the special fertilizers applied. A fourth example may be given: The land needs all three of the fertilizers. The farmer spreads on one plot or field burnt bone (phosphoric acid only), on the other sulphate of potash, on a third nitrate of soda and potash, on a fourth potash and burnt bone. It is possible that not one of these fields or plots will yield a full crop, and the experimenter arrives at the erroneous conclusion that chemical fertilizers are worthless upon his land. His land needs all three and is not satisfied with any one or two. If we would ascertain whether a given piece of land needs a special or complete food, a complete fertilizer should be used on one plot, and upon another, a fertilizer from which one or another of its constituents is omitted. And it may be necessary to repeat this several

years. A comparison then between the several crops would be likely to answer the question whether the omitted constituent was the one most needed or not at all needed. But there is still another cause which might mislead farmers as to the effects of chemical fertilizers, or other chemicals used as such. We allude to the action of certain substances which are either not plant-foods or incomplete foods. Such, for example, are salt, plaster, lime, sulphate or muriate of potash, nitrate of soda or sulphate of ammonia, etc. The fact that any one of these has greatly increased crops would not prove that the land needed it ; it would not even prove that the substance was a plant-food. The increased crop might be due to food in the soil, previously inert, rendered soluble by the salt, plaster, lime, nitrate of soda, or potash. In other words, their action was essentially that of a stimulant, because the land has been forced to yield up what it was otherwise powerless to have done. So it is that certain more or less impoverished soils may be lashed into yielding abundantly, while every year becoming poorer, until they become so exhausted that they have nothing more for the time to give. Everything has been taken from them, and now every thing must be supplied. A neighboring farmer ten years ago told the writer that his father had "brought up" his farm by lime, and that he (the son) proposed to continue its use. He has since changed his mind, for the reason that he cannot raise paying crops without manure or fertilizers, no matter how much lime is used. How many readers have had a similar experience ? We may here call attention to the fact, not generally considered, that two "*complete*" fertilizers which analyze the same, may yet give very different results, not because the food of the one is more available than that of the other, as when leather or shoddy is employed to furnish nitrogen, or undissolved South Carolina rock phosphoric acid, but because in the one different forms of the same constituent may be used. Thus, for example, in a potato fertilizer, if the nitrogen were furnished by bone and blood, both slowly soluble, we should not look for so large a yield as if nitrate of soda and sulphate of ammonia were added. What is needed is food *adapted to the plant from the beginning to maturity, so that it shall not suffer during any period of its growth*, in so far as abundant and assimilable food can prevent. And these facts, which are positively known to be facts, we would gladly, by iteration and reiteration, if necessary, impress upon those

readers who, through perfunctory investigations or from merely jumping at conclusions without any rational data to guide them, denounce concentrated fertilizers as worthless.

HOW MONEY IS THROWN AWAY.

Suppose, as has previously been said, we should separate farm manure into three parts, viz, : phosphoric acid, potash and nitrogen, the three constituents which, as we have had it drummed into us for many years, all plants must be supplied with, and which impoverished soils do not furnish in available forms. Suppose that we give a crop a large quantity of *one* of these constituents, and that the crop shows no benefit from the application ; would that prove farm manure to be ineffectual ? Not at all. Suppose we sow super-phosphate or potash, or nitrogen, upon our soil—only one, or even two—and the crop is not appreciably better ; would that prove that the so-called chemical fertilizers are of no use ? It would prove just exactly as much in the one case as in the other. It would only prove one of two things ; first, that the soil was rich and needed no plant food, or second, that the soil was so impoverished that it needed *all.*

If farmers buy bone ash, which furnishes only phosphoric acid ; or sulphate or muriate of potash, which furnishes only potash ; or nitrate of soda or sulphate of ammonia, which furnishes only nitrogen, and spread it upon a poor soil which needs *all three*, they will get no adequate increase of crops—and they may rely upon it. But they must not, therefore, condemn the use of concentrated fertilizers. In this connection, let me ask the reader again to refer to the effects of the various fertilizers upon potatoes raised upon my "worn-out" soil. Is not the lesson taught by them conclusive ? Potash, as it exists in kainit, applied at the rate of two tons to the acre, gave no increase in the yield. Burnt bone had little effect. Nitrogen was not effective, except (in most cases) to make an early promise which was broken later. But the *complete* fertilizers gave large yields.

I conjure you, farmers (and I would repeat it again and again), unless you desire to throw your money away—do not buy special or low grade fertilizers, unless by actual tests you happen to know just what your land needs. A cheap fertilizer means one that supplies a low per cent. of plant-food ; or else it means a special or comparatively

worthless fertilizer, like ground leather, hair, wool, plaster, salt or something of the kind.

Suppose you apply 1,000 pounds of bone-flour to your land each year for 10 years. Finding it of great service for five years, it is continued. But the farmer finds, later, that it does not increase his crops at all. He might naturally, though erroneously, call his land "bone-sick." Now, let him apply potash and the land responds at once, giving the finest crop ever raised upon the farm. The trouble was, not that the land had too much bone or phosphoric acid, but too little potash. The crops had appropriated all the available potash and could not live on bones alone. So, in like manner, land might seem to become "potash-sick." In such a case bone-flour would prove a specific cure. Farmers should not overlook the fact that when an imperfect food alone is furnished to plants, they cannot thrive unless the soil supplies the constituents which the imperfect food does not supply. In the course of time the land yields up its present store and a perfect food must be supplied.

A TALK WITH FARMERS ABOUT CHEMICAL FERTILIZERS.

The following is almost a *verbatim* report of talks I have had with farmers living about us. It may serve to emphasize what has previously been said upon the rational use of fertilizers. See also Chapter XVIII.

FARMER A.

"How did your potatoes turn out?"

Farmer A.: "Those manured with farm manure plowed in last fall yielded 200 bushels to the acre. Those upon which I used 'phosphates' yielded about 150."

"What was the 'phosphate'?"

A.: "I don't know. I bought it for $20 a ton."

"Did you ever try a higher grade of fertilizer?"

A.: "Yes. Last year I paid $30 a ton, and spread it on rye at the rate of 500 pounds to the acre. I left a piece about 50 feet square without any 'phosphate'. This piece was just as good as the rest. Once I tried kainit, but it did not increase the crop of corn. There is nothing like farm manure, if I could only afford to buy it. Lime is the best fertilizer for me. It has done my land more good than all your 'phosphates.'"

"What do you understand by the word 'phosphate'?"

A.: "I understand it to mean chemical fertilizers."

"And what are the chemical fertilizers made of?"

A.: "Of 'phosphates', I suppose."

"Here we have a 'phosphate' that costs $45 per ton, and here is another brand for $20. Why is it, think you, that many farmers prefer the $45 'phosphate'?"

A.: "I cannot say. I should feel that I was throwing away my money. My idea was to experiment with the low-priced fertilizer first and if I found it increased my crops, I then proposed to try a higher-priced article. But my opinion is that 'phosphates' don't pay on my farm."

FARMER B.

"Do you use chemical fertilizers?"

Farmer B.: "No. I use lime. My father before me brought up this farm with lime, and I use it in preference to anything else, except manure."

"Do you buy manure?"

B.: "No. I use what we make from our two horses, four cows, from the pigs and poultry. My farm consists of 70 acres."

"Do you raise wheat?"

B.: "No, we cannot raise wheat any more. Besides, rye pays better. The straw always brings a good price."

"And why cannot you raise wheat?"

A.: "Oh! the climate seems to have changed, or at any rate the farm does not seem to be adapted to it any longer."

"And how about corn? Can you raise as much corn as you could years ago?"

B.: "Field corn is no longer a paying crop with me. I raise sweet corn, manuring it in the hill, and send it to market. Sweet corn, lima beans and tomatoes pay me best. All are well manured in the hill."

"Do you raise clover?"

B.: "Yes, we seed to timothy and clover after sweet corn. But clover is uncertain now-a-days. Sometimes we get a catch, oftener not. The same change of climate seems to be the cause. Years ago, we could raise peaches here in abundance. Now they are of no account, and so it goes."

"Do you think that lime supplies to the soil all the food that plants take from it?"

B.: "That's an old story. No, probably not. But I believe that the soil is practically inexhaustible, and that lime makes its food soluble as our crops need it. My belief is that chemical fertilizers pass through the soil, so that nothing remains after the first season."

"Probably you are aware that J. B. Lawes, of England, has raised crops with fertilizers alone for over 45 years, and that he harvests as large crops as by the use of farm manure, which for the same length of time has been applied to other plots of the same crops."

"Does it pay him?"

"The money equivalent is about the same upon both plots."

B.: "I believe that all editors of farm papers advocate the use of fertilizers. They seem to have great faith in quack medicines also. I receive probably fifty free specimen copies every season. They are full of all sorts of fraudulent advertisements. In one column they advocate temperance; they declare that they will not insert unreliable advertisements at any price. In other columns I find advertisements of bitters, which are alcohol in part; of positive cures for consumption, fits, deafness, cancer; of mines and land schemes; of British claim agencies and all sorts of frauds, which are frauds upon the face of them. You editors can't afford to tell the truth about these things. You would lose your advertising patronage. Editors run their papers to make money, and you must crack up chemical fertilizers."

"Do you read the daily or religious papers?"

B.: "Yes, I read the weekly issue of the daily papers and a weekly religious paper."

"And do you find that they are more careful to exclude unreliable advertisements?"

B.: "Not at all. I have no faith in the integrity and sincerity of editors. There is no class of teachers so given to lying; no class that so set themselves up on a high pinnacle of morality, that are so ready to bob up or down according to the pay they receive."

FARMER C.

Farmer C.: "I have never tried chemical fertilizers, but think of doing so. Which make would you advise me to buy, and what price to pay?"

"The price depends upon the quality of the fertilizer. All reliable manufacturers charge about the same price for the same quality. Which gives the most plant food for the money can only be ascertained by chemical analyses, and these do not always show the agricultural value. One article might show as high a per cent. of nitrogen as another, while in one case the nitrogen is in leather or hair, and not available as plant food, and in the other the nitrogen is in nitrate of soda or sulphate of ammonia, which is in a soluble form. The phosphoric acid in one may be in bone, in the other in raw South Carolina rock. The first is worth seven cents, the second only two cents a pound. The way to find out what fertilizer to buy is to find out what kind your land needs. This can only be done by using the various constituents separately and in varying combinations. In the absence of this information, what are called complete fertilizers should preferably be used; that is, those which furnish all kinds of plant food in which the soil is probably deficient."

C.: "And what do they cost?"

"From the lowest to the highest price. One firm may sell a complete fertilizer for $20 a ton—complete because it contains one or the other forms of phosphate, potash and nitrogen—another may cost $60 a ton, because it contains a higher per cent. of the same constituents."

C.: "Which am I to choose then?"

"It is merely a question of the cost of transportation and application. Here are two fertilizers, one costing $25 a ton and the other $50. We will suppose that the first contains just half the plant food that the second contains. You pay half price and have twice as much to spread on your land and twice as much to pay freight and carriage upon."

FARMER D.

Farmer D.: "I understand that you recommend a complete fertilizer if a farmer has determined to use fertilizers, and does not know just what his land needs. You say that a complete fertilizer means one that contains phosphoric acid, potash and nitrogen. The land is supposed to have a supply of the rest. Do not raw-bone and potash make a complete fertilizer?"

"The word complete is an unfortunate one as applied to fertilizers,

the same as "phosphate," because both are misleading. A complete fertilizer could be made up that would be worth less than $5 a ton. Muck, containing a trace of each of the three plant foods, would be as complete in the mercantile sense as if it contained large percentages."

D.: "Raw-bone contains phosphoric acid and nitrogen. Suppose we add potash in any form, would that not be a good complete fertilizer?"

"Not the best. Raw-bone is slow to decompose. Neither its nitrogen nor phosphoric acid is immediately available. Besides its per cent. of nitrogen is rather low, being less generally than three per cent. Probably the best fertilizers are made up of many different sorts of plant food. For example, the nitrogen may be supplied by fish, nitrate of soda, sulphate of ammonia, blood and guano. In such fertilizers, the nitrogen is available trom the beginning to the end of the plant's life. First, the nitrate of soda is at once ready for the plant; then the sulphate of ammonia; then the guano, blood and fish. It is the same with phosphoric acid. This should be furnished by super-phosphate first, then by raw-bone, etc., so that the plant shall have a ready supply at every stage of its growth."

D.: "How am I to be assured that I get all this, even though I buy the highest grades of fertilizers?"

"You can't. All you can do is to buy of reputable firms who agree to sell you what you ask for. The analyses, as published in the bulletins periodically issued by experiment stations, are helpful guides; the crops must show the rest."

D.: "My neighbor used 600 pounds to the acre of high-grade $40-fertilizer last season on his corn. The crop was very poor."

"And the season was dry?"

D.: "Yes."

"Have you never known farm manure to fail in such a season?"

D.: "Do you advise farmers to use fertilizers?"

"It is far beyond any one to advise in the matter, further than to say that farmers cannot use them to the best advantage, except by chance, unless they study the science of fertilizers as they would study a book, and then, with the light of such knowledge, experiment with them in their own fields. Each farmer would then be enabled to answer the question for himself. No one can answer it for him.

THE POTATO'S NEEDS.

To sum up the demand of successful potato culture, a farmer must know, by actual trial on his own grounds, what varieties succeed best, in order to insure the best results; also, if possible, at what season he had best plant his crop so that it may be supported by plentiful rain-falls at the time of the setting of the tubers; also the fields best adapted to the growth of potatoes; then he must act accordingly. In a series of years a farmer, acting on such general principles, will be more likely to be successful than one who plants such sorts as he may have on hand, and at such times as best suits his convenience, without regard to the quality of the seed or its adaptedness to his soil, as it is now a well established fact that a variety that succeeds well in some localities, is comparatively worthless in others.

A mellow soil, a moist soil well drained; plenty of potash, nitrogen, phosphoric acid, lime, and possibly magnesia, sulphur and salt, for mechanical effects, or for an effect not understood; give the seed pieces enough flesh to support them until the shoots can be supported by their own roots. Plant them in depth according to the soil, whether inclining to clay or sand, from three inches to five inches. The distance of the hills or drills, and the pieces in them, should be regulated by the vigor and size of the varieties planted. Rank-growing varieties, the same as tall-growing corn, will not yield well if planted too closely together. Hilling-up on well drained land never increases the crop. The fibrous roots extend from hill to hill, from row to row, and the soil should not be taken from them to heap it up about the stems where it is not needed. In hill culture, where the tubers crowd each other out of the ground, hilling-up is necessary only to protect the potatoes from the air and light. Broadcast manuring is better than manuring in the hill, for the reason that it is the fibrous roots that need the food—*not* the tubers, which are fed by the fibrous roots. Kill the potato beetles before they have injured the foliage. *Any* injury to the foliage will impair the vigor of the plant, and less vigor in the plant means less crop.

THE DIFFERENCE.

It is unfortunate that the name "chemical fertilizer" should be generally accepted as something different from "manure.' They are

precisely the same thing. That is to say, if we desire to answer the question, "What is manure?" we must answer that it consists of just those constituents which by chemists are called nitrogen, sulphuric acid, gypsum, potash, copperas, ammonia, magnesia, silicon, etc. If we burn a quantity of straw, grass, wood, flesh or any other substance, we have the ash constituents remaining. *They* are the so-called chemical fertilizers, excepting that the nitrogen, carbon, oxygen, hydrogen, etc., have escaped in the form of gas. If we take a rock and pound it to a very fine powder, we have a manure or fertilizer, and its value depends upon its content of those materials which plants need. We do not consider bone or South Carolina rock a chemical fertilizer *per se*, and yet either is, in fact, just as much a chemical fertilizer as is nitrate of soda, sulphate of ammonia, muriate or sulphate of potash, for the reason that they are valuable as a plant food only as they contain those substances. It is just the same with any kind of manure. The essential difference between farm manure and chemical fertilizers is that the former is bulky, slow to decay, yielding up to plants its nourishing elements not until they have become soluble by slow combustion. While, too, this *bulk* is decomposing, it exerts a mechanical influence on the soil, making it lighter, admitting more air and moisture to the plants, which are hungry to avail themselves of either.

It is with agricultural chemists as with other scientific individuals—they are not aware to what extent the employment of so-called scientific terms renders their work Greek to the mass of those they seek to instruct. If farmers were at once to understand that chemical fertilizers are merely *concentrated farm manure*, they would not be so prone to regard a sufficient understanding of the action of these fertilizers as something beyond their comprehension without an amount of study which they believe themselves unable to give to the subject. *Concentrated* manure and *farm* manure would be the better names to give respectively to the waste products of the farm and to those self-same products which are now known only as "chemical fertilizers."

CHAPTER XV.

Seedling Potatoes. How to plant the seed and treat the seedlings. Every gardener and farmer should raise his own varieties. How to select. Should we save tubers from the most productive hills? Why the same variety varies.

IT IS NOW some fifteen years ago that I began to raise potatoes from *seed*. Previous to that time, raising potatoes from seed was supposed to be a very hard thing to do; there were "secrets about it known only to a few," I was told, upon inquiry of a leading seedsman of those days. The seed and seedlings needed "bottom heat," and thereafter even temperature and steady moisture, such as could be given only in glass structures fitted especially for such work. The truth is, as many of my readers are now aware, that potato seeds germinate somewhat more readily than tomato seeds, and, until set out in the open ground, may be treated in precisely the same way. From the time that I found this out up to this day, I have advocated seedling potato culture, through the farm press. New varieties of potatoes are absolutely necessary from time to time. All varieties, after a time, degenerate or "run out," as most farmers select their "seed." Millions of dollars have been spent for new potato "seed," that might just as well have been raised at home.

SEED BALLS OR FRUIT.

Let us gather the seed balls, apples, or whatever one chooses to call them, from the potato vines as soon as they begin to die. These

may be kept until they begin to wither or rot, when the flesh is parted from the seed and the latter dried and preserved the same as any other seeds, until sowing time arrives. The seed ball of a potato is the proper fruit, as the tomato is the fruit of the tomato plant. The tuber of a potato is merely a swollen underground stem, quite distinct from the roots. Indeed, tubers often form above ground in the axils of the green stems, as no doubt readers have had occasion to notice. The so-called "eyes" of the potato tuber are buds which, as we also know, push and form stems and leaves feeding upon the decomposing flesh of the tuber itself. Potatoes may be, and are, grown from these stems, and in this way large quantities may be raised from a single tuber by pulling off the shoots and planting them as they grow. But this is a branch of the subject which is treated elsewhere.

In times gone by potato plants fruited plentifully, and potato apples could be procured in unlimited quantities. It is different now. Many of our present kinds do not fruit at all—some of them do not even bloom. Twelve years ago I raised 62 different varieties and was unable either to procure any pollen for the purpose of crossing, or a single seed ball. The past season, of 50 different kinds, ten bore seed balls, one—Wall's Orange—in large quantities, a cluster of which is shown at Fig. 14, p. 139. When it is considered that potatoes have been bred and cultivated for the tubers alone, it is not surprising, perhaps, that the plants should incline to fruit less and less with every year. Some say that the yield of potatoes 50 years ago was greater than now, and that, therefore, the potato is less productive now than then. This, while perhaps true in fact, is no doubt an erroneous view as to the cause. If our ancestors had had our present varieties they would probably have produced very much larger crops. The buds or eyes of potatoes sometimes vary, as has been stated, producing potatoes that differ in quality, in color or in time of maturing. Thus we have the Late Rose, Beauty of Hebron, etc., from Early Rose and Beauty of Hebron. But potatoes never "mix in the hill" from contact, as some suppose. We can produce new varieties at will only from the seed.

SELECTION OF SEEDS.

It seems hardly necessary to advise that balls from the best varieties should alone be saved—the best yielders, the best in quality, in shape; the best keepers and those which are least liable to disease. If our own potato vines produce no balls, probably they may be found in our neighbors' fields or patches. If they too fail, we may write to friends in other states or localities or we may purchase them of seedsmen. We will suppose that the reader has neither greenhouses nor plant frames of any kind. We should next require a sunny window facing the east or south or, better, southeast, and a room in which the temperature never falls below 35 degrees.

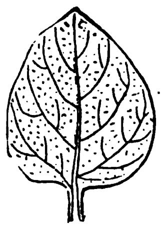


FIG. 12.

PLANTING.

Provide well-drained flower pots, filled with mellow garden soil. Press the soil firmly with the bottom of another flower pot. Then sow the seeds evenly half-an-inch apart and cover with one-eighth inch of soil, and again press the soil—this time lightly. Place these pots in pans or buckets of water so that the water comes up outside the pots nearly as high as the surface of the soil, and leave them until the surface soil begins to show it is wet. Remove them then to the sunny window and cover each with glass. So treated they will need no more water until germination takes place, which will be in about a week or ten days. The glasses may be removed as soon as most of the seeds have sprouted. It is better, however, to remove the glass gradually, first by raising it an eighth of an inch, then a quarter and finally lifting it off entirely. We prefer this method of supplying water to surface-watering for several reasons, chief among which is that the soil is not washed off the seed. The first leaves appear as in Fig. 13 A, the later leaves as in Fig. 13 B. We should advise that the seeds be sown not until late February, or early March. The little plants will then be large enough to transplant to little pots (say three inches in diameter) by early April. A pocket-knife blade is as good as anything for the purpose of "pricking out" the plants, only one of which should be planted in each thumb-pot.

CARE OF THE PLANTS.

By April 20 many leaves will be found to be of the shape and size of Fig. 12, while the plants will have reached the average height of four inches—some strong, some puny. The one thing now to be borne in mind is that these seedlings do not receive a check from over or insufficient watering, from too much or too little heat, or from any other cause, otherwise the swelling stems or little tubers will cease to grow or they will make a second growth.

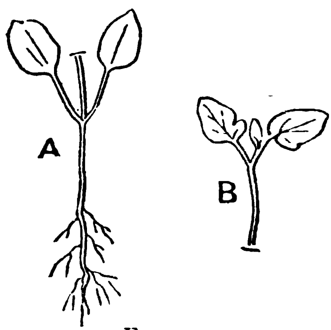


FIG. 13.

As soon as all danger of frost is over, we may now transplant our seedling vines to a warm, well prepared plot. Dig little holes with a trowel, one foot apart, in drills three feet apart, and thump the balls of earth, which will be held firmly together by the fibrous roots of the plants, out of the pots and set them firmly in these holes. Thereafter their treatment will be the same as potato plants from eyes.

If it be desired to raise the largest crop and the largest tubers from seed, and one has a greenhouse, the seed may be sown in January. As the little pots into which the seedlings are transplanted become filled with roots, they (the seedlings) may be thumped out and placed in larger pots. Set out in the open, as above described, after there is no longer danger of frost, the tops will grow as large as those of other plants, while many of the tubers will be found to be of marketable size.

Our view has been that farmers may raise seedlings that will be found to be better adapted to their farms than most of the hundreds of kinds offered for sale. Then again in the case of a lucky hit, the variety might be sold to some enterprising seedsman for a price that would well repay the producer for all his time and trouble. The seeds will sprout about as readily as tomato seeds. The trouble begins when the little tender plants are set out in the open ground. The beetles attack both leaf and stem and destroy them in a few days. The seedlings *cannot be saved* by any application of arsenic or other poisons.

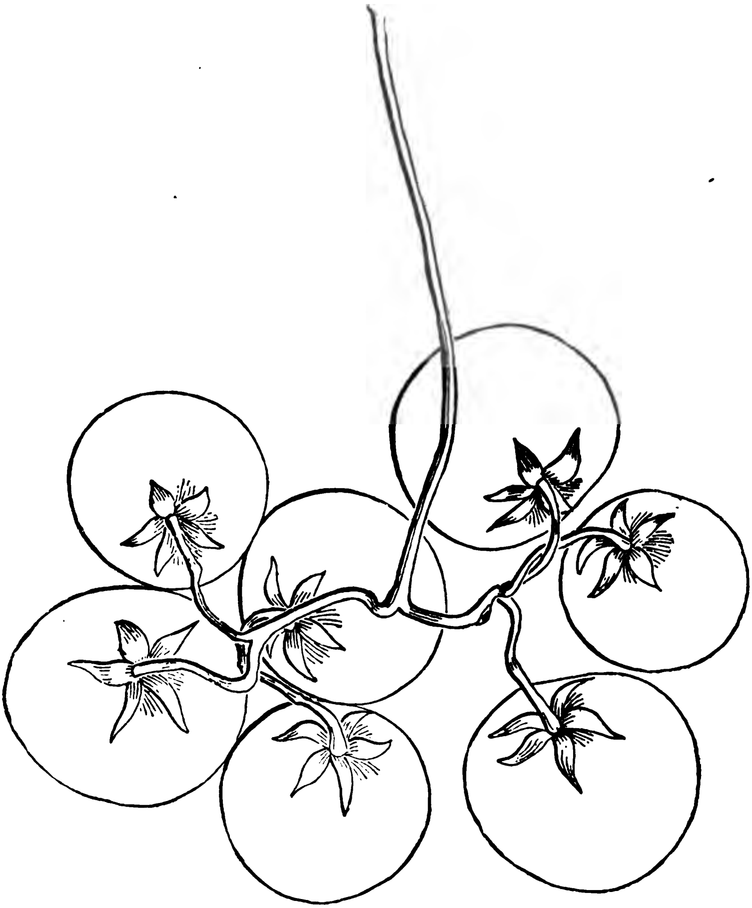


Fig. 14.
Fruit balls of Wall's Orange potato.

The injury to the leaves and stems which the beetles or grubs will eat before the poison kills them will destroy the vines. Besides they are so tender that they cannot even stand the plaster alone—much less poisoned plaster.

As soon as the seedlings are set in the garden, mosquito netting, one yard wide, is stretched lengthwise of the rows and supported above the vines by half-hoops or sticks, placed at intervals of four feet, like the rafters of a double pitch roof, and the peaks are connected by horizontal sticks tied to the peaks, or where the two sticks meet, giving all needed support to the netting above, while the edges on either side are held in place below merely by covering them with an inch of soil, or by narrow boards. We have now a two-pitched or oval covering, which is quickly made and at merely the cost of the netting. This protects the vines thoroughly until they fill the triangular or oval space, when they are large and strong enough to stand poisoned plaster, and the netting may be removed, to be used a second time the next season.

SHOULD WE SELECT SEED POTATOES FROM THE MOST PRODUCTIVE HILLS?

Some years ago, Dr. Sturtevant, the director of the New York Experiment Station at the time, stated that he found that potatoes selected for "seed" from the most prolific hills gave greater yields than the "seed" selected from hills yielding the smallest number and weight of tubers.

The late Peter Henderson, commenting upon this, took the view that "further experiments will show that this increased productiveness will not continue to hold, because the reason for the greater or less yield was probably only an accident of circumstances, due to specially favorable conditions of the set made to form the hill, or to being highly fertilized, or to some such cause that gave it this temporary advantage; and that the chances are all against any permanent improvement being made by such selections."

This is certainly a very important question. A potato, it must be repeated, is a peculiar stem, with buds. Its peculiarity is that which gives it value as food, which is starchy, tender and wholesome. When these swollen stems are planted, the buds (eyes) grow, the same as any other buds, and from the underground portion of these shoots issue roots and other stems, the extremities of which swell, forming tubers. Some of these grow large and shapely; others small and ill shapen. Still others are just beginning to form as the season ad-

vances, even as the vines die and the tubers are harvested. Every so-called variety of potato has, when all its needs are supplied, a certain limit as to size and perfection. *All tubers which do not so develop are retarded or injured in one way or another.* Some are harmed by drought or by too much moisture; some by insects; while the shape is modified by the heaviness or lightness of the soil, by stones or by growing too close together. Potatoes grown in pure sand, and fed with liquid food, are, as we have shown, always smooth and perfect in form; that is, perfect, according to the standard of the particular variety cultivated. It may well be thought that any irregularity in shape, due to stones or a too compact soil, etc., would never be repeated and become fixed were such deformed potatoes planted again and again. It seems reasonable, however, to suppose that those tubers which are harmed by parasites, or rot, or insects, have thereby sustained injuries which, decomposing the tissue, must weaken the virility of the buds and shoots. The smaller and smallest potatoes of a crop are those which have been dwarfed from some cause. The formation of more tubers than the parent plant could support is, perhaps, one cause; and the formation of tubers too late to mature is, no doubt, another. It may be a matter of pure conjecture whether, in the former case, the dwarfed potatoes are possessed of as much vigor as the largest one. But, in the latter case, all analogies point to the conclusion that immature tubers, as well as immature cuttings of any kind, will produce comparatively feeble plants. This is well exemplified by the weakened constitution of grape-vines grown from green wood.

What is called "bud variation" is, as is well known, common enough. Thus it is we have many of our most prized ornamental plants, as, for example, weeping and variegated trees, shrubs and house plants. The writer has in mind a willow, a few branches of which bore leaves splashed and striped with bright yellow. By starting cuttings from the variegated shoots for several generations, the variegation has become fixed, while the original tree has lost its variegation. Similar cases often occur with potatoes. We have now a purple-skinned potato that matured on a plant all the other tubers of which were buff-skinned, and the potatoes are notably different in quality. If such qualities may be fixed by selection, why may not also increased productiveness be fixed by selection? Let us now

speak of the variations which occur in young and seedling potatoes, which, we fancy, will give emphasis to the view we have taken, viz: that productiveness may be increased by selecting, not only tubers from the best hills, but, it may be added, from the shapeliest and most perfect individuals in such hills.

Let us sow seeds—true seeds from the fruit or seed-ball. Each plant may produce, let us say 15 tubers, varying in size from a pea to an egg. They will also vary in shape. Some will be round and smooth; others pointed at the ends, others long and slender. Every experienced seedling potato grower knows that he can generally secure the shape desired by planting tubers *of that shape* and then again selecting the same shape for the next crop, until the variety is considered established and ready to turn upon the market. From the same seedling plant, therefore, he can oftentimes propagate varieties which shall be round, flattened, cylindrical, or "kidney" shaped. Seedling potatoes often, also, vary in color, and the color can be fixed by selection, as just described. No less does the *productiveness* of tubers from the same seedling plant vary. This I have seen in my experience again and again. The tubers from an original seedling plant will vary in yield as much as they will vary in shape or color, or in depth of eyes. I do not know the practice of *all* originators of new potatoes, but I do know that *some* of them select for the second planting those tubers which closely resemble one another in shape and general appearance without the least regard for or any knowledge of their different yielding powers. The next season selection is again made from these according to appearance, time of ripening, etc. Finally the new variety is ready to be sold. The tubers bring from 25 cents to $1 a pound, and single potatoes are sent all over the country. Is it surprising that many report that the new potato is immensely productive, while others report otherwise? Further than this: I know of seedling potato growers that select tubers from *more* than one hill if the seed planted is the same and the *appearance* of tubers of the different seedlings is the same. According to this, a dozen or more kinds differing in productiveness and in quality are sent out *under the same name*. Evidently we should gain in such cases by selecting the best tubers of the most productive hills. Evidently again, farmer Jones may find the new seedling of a better quality and a greater yielder than farmer Brown, who purchased the "seed"

from the same seedsman, and gave the same or even better cultivation. The fact is that the two men plant and raise potatoes which are really different in quality and productiveness, though to all outward appearances they are much the same.

LET IT BE REPEATED.

Of seed tubers, save only the *largest* and *shapeliest* from the most *productive hills* for future propagation, and *start a variety from a single tuber.*

CHAPTER XVI.

Care of the seed. Exposing sound seed to light and sun before planting. How to detect impotent eyes. Lime as a preserver. Handling. Digging potatoes by machinery. Poisoning.

IT IS my opinion that it will pay farmers to place their seed-pieces (if sound, that is, not sprouted) in light, sunny places ten days before planting time. They can then cut their seed intelligently, according to the number and vigor of the eyes. In this way a perfect stand may be secured, and it may be doubted if it can be secured in any other way. The seed, of course, must be kept sound, or nothing can be gained by the exposure to light and warmth. Probably seed raised in Ohio or Pennsylvania or Illinois will yield just as well as seed from Maine or Canada, provided it can be *kept from sprouting*.

Let us place our sound seed then in a temperature of 70 degrees for ten days. All the potent eyes will develop a short, stubby, warty growth not easily broken off in the usual handling, and the tubers may be cut accordingly.

Mr. G. W. P. Jerrard, of Caribou, Maine, plants his seed potatoes fresh from his cool cellars when they are nearly as dormant as when dug in the autumn before. He finds they come through the ground with a big vigorous shoot and maintain a superior vigor all through the season. Seed potatoes from which sprouts have been removed once or more, lack vitality as compared with fresh ones. He stores his potatoes in deep, cool cellars, in bins 4 feet wide and 3½ feet deep, one above another, two high, with a floor and air space between them. They have plenty of air in the fall, but not in the spring, and they do not sprout until June.

Mr. Geo. E. Waring, a correspondent, says that while we all know that a low temperature prevents tubers from sprouting, it is not generally known that cold much below 40 degrees and quite above freezing, will permanently impair their power of germination. Seed potatoes should be kept with much care in this respect, at a few degrees higher than is best for winter apples, and never too low, even for a short time.

LIME

has often been recommended as a preventive of potato rot. The N. Y. Experiment Station does not find it so. The Director filled two barrels with sound White Star potatoes, in the fall of 1883, in one of which he sprinkled air-slaked lime, as the tubers were put in, in sufficient quantity to whiten them. On April 3d, the potatoes in both barrels were examined. The one treated with lime had 68 decayed tubers, while the other contained but 52. It thus appears that in this experiment the lime exerted no beneficial influence.

Many people are in favor of leaving potatoes in the ground to the latest safe hour, say early November, and this even for those maturing in July. Taking one season with another, this has been the writer's experience—an experience rendered necessary, in great part, in order to secure to his experiments equivalent conditions.

HANDLING.

A friend writes that he has tried several ways of harvesting potatoes, but finds that if good help can be had, digging by hand is the best. Last year his men dug with a potato fork, taking two rows each and going backward, throwing the potatoes from the two rows together, leaving them in good shape to pick up. He had one man that would dig 100 bushels every day, and dig them clean. His potatoes are sorted in the field; to do the job there requires less time and labor than when left for some other time. Small potatoes are drawn into the barn and fed to the cows, except several barrels that are put into the cellar to be cooked and fed to the chickens during the winter.

Another correspondent writes that he digs his potatoes by hand, with hooks; he prefers hooks to forks, hoes or diggers; he can get

all the potatoes in a hill without bruising them. He always sorts in the field, making two pickings. Small potatoes are fed to stock. Owing to the waste of shrinkage, interest, resorting, frost, rotting and other risks one must run, the chances of an extra price in spring are not enough to pay for holding over.

A third writes that if the potatoes are to be shipped in bulk in a car, or put directly into the cellar, the cheapest way to handle them is in sacks. Scatter the sacks along so they will be convenient, and pick the potatoes up into small baskets, so that you can hold the sack and empty the potatoes into it without help. Then put only a bushel into a sack; one man can easily throw this into the wagon without help, and there will be no need of tying a sack only half full. With one man in the wagon to place the sacks, and two to hand them up, it is the work of a very few moments to load, and the unloading can be done as rapidly.

Every person who raises many potatoes, writes a fourth friend, should have a number of small boxes holding about a bushel each. These can be placed along the rows and filled from the ground. They should be placed in the wagon and not emptied until the barn or cellar is reached. Most farmers handle their potatoes over three or four times in passing from the ground to the bin. Why handle them unnecessarily? What must we think of a farmer who has to mow down the weeds on his patch in order to find his potatoes?

DIGGING POTATOES BY MACHINERY.

An expert can dig half an acre even of drilled potatoes, in a day of ten hours, if the crop is clean. But ordinary men would be about three days digging an acre. The cost of this amount of labor, including the board, would be about $4. There are more farmers who get their potatoes dug at a greater cost per acre than this, than there are who pay less. Thus writes Mr. T. B. Terry, of Ohio, who has been very successful in potato farming. For three years past he has used a digger, which cost $100. Hand labor has been entirely dispensed with, except at the ends of the field and when digging unripe potatoes for the market. About an hour's work in the morning, and as much more after dinner, would dig as many potatoes as his help would pick up. With the conditions all just right, he has dug an acre in two hours, but ordinarily it would take about three.

Instead of paying out about $50 a season for extra help to dig his crop, the machine now does it, and he hardly misses the time spent in riding on it, and of course he pockets the $50. This is more than literally true now, for of course the machine has more than saved its first cost. Again, he can rush business, putting all the help at picking up. He is quite independent, also, for any one can pick up, but few can dig well and fast. The machine wears fast, but probably $10 would cover the wear to date. In replying to a question which I asked Mr. Terry, he says that he has always practiced shallow cultivation until the growth of vines prevented it. It is true, as he believes, that the "trenches" render cultivation less necessary, but it is nevertheless of the first importance if we would secure a maximum yield. Keep the surface soil mellow as long as possible. Plants cannot do their best in a compact soil—it matters not what the plant is —a rose, a pansy, a corn or potato plant. If I have endeavored to impress one thing more than another upon my readers it is the importance of a mellow surface during plant growth. I began its advocacy years ago when, upon a measured acre of land, I raised over 130 bushels of shelled corn. At the same time I began the advocacy of shallow cultivation for corn—since extended to potatoes. When I began to talk of shallow cultivation for corn, other journals were commending the "root pruning" absurdity. Now, there are few good farmers who care to sever the roots of the growing corn, and it is evident that shallow cultivation for potatoes is all the while gaining friends.

PARIS GREEN.

I am of the opinion now, as I have been for several years past, that the most economical way to apply Paris green is to thoroughly mix it with plaster, as previously described, rather than with water. In the latter the poison cannot be equally distributed, stir the water as we may. The upper portions of the water will always hold less than the lower portions, where the insoluble heavy powder collects in larger quantity in spite of constant stirring. The leaves of the potato plant are harmed by this. Not so with flour or plaster. While we must use a dessertspoonful of the green to a pailful of water to render it effective, the same quantity thoroughly mixed with two pailfuls of plaster will prove just as effectual.

Again, much of the water applied falls to the ground. A part only is retained on the leaves, while nearly all of the poisoned plaster, if skilfully applied, falls upon and is retained by the leaves until the next rain. The poiscned water, for the most part, does not settle or dry upon the edges of the leaves, but the poison collects as the water evaporates near the center or mid-veins or depressions, so that the beetles may eat up the best part of the leaf ere they encounter the poison, and the leaves are for the most part destroyed.

PICKING OFF THE BEETLES.

Nobody that speaks from experience, as it seems to me, will advise people to pick off the first potato beetles (parent beetles) by hand in order to save work later on when the eggs hatch out. We tried this plan thoroughly for several years, and an estimate was kept and published of how many beetles were thus gathered and destroyed daily. But it seemed in a great measure a loss of time and toil. It is true enough that if all the parent beetles are destroyed, there will be no grubs. But this is impracticable. A large proportion at any given time are concealed under the soil, while others are creeping from place to place, not to speak of those that come from neighboring premises. In spite of our care in destroying the beetles and eggs, myriads of grubs appeared, and we were at length driven to use Paris green the same as in previous years. When writers advise us, as many have done, to gather the beetles by hand, we want to tell them that if they would practice this advice for one season they would not care to offer it again.

CHAPTER XVII.

THE LATEST POTATO EXPERIMENTS MADE AT THE "RURAL" GROUNDS.

Experiments during a dry season and in a variable soil. Does the high-grade potato fertilizer furnish enough nitrogen? Does it pay to use nitrate of potash (saltpeter) rather than nitrogen and potash in other forms? The carefullest experiminents with fertilizers may yield contradictory results during a droughty season and in a variable soil. The effects of high-grade fertilizers used from 440 to 1,320 pounds to the acre. The effects of nitrogen alone and of from 55 to 440 pounds of nitrate of soda and nitrate of potash to the acre used alone and added to high-grade potato fertilizers. The effects of snuff used in quantities from 1,760 to 3,520 pounds to the acre, with and without added nitrogen and potash. Trials with Mapes's, Bowker's and Bradley's fertilizers separately and Combined.

THE land, upon which this series of experiments was tried is notably variable, and necessarily so, a fact that studious readers will need to understand and bear in mind if they hope to learn anything from this series of experiments—102 in number.

Four years ago the land was a dead level, and so imperfectly drained that water, after heavy rains, remained upon parts for several days.

Three years ago it was so graded that the land was made to slope

gently from the east to the west, and the surplus water to run into a ditch three feet deep, dug along the western boundary. This was effected by casting the soil of the western portion first to the easternmost portion, and in smaller quantity as the western boundary was neared. A soil varying in depth and fertility in every part was the consequence. Last year sweet corn was raised upon it, fertilized with 800 pounds to the acre of the Mapes Potato Manure. With this exception it had never received either fertilizer or manure. The field, varying from a sandy loam to a clay loam, with a varying subsoil from a brick clay in some places to sand in others, has always been thought by native farmers of such low natural fertility that no one cared to cultivate it.

The season was one of excessive dryness. Many wells in the neighborhood never known to fail before were dry for six weeks during the late summer and fall. There were few beetles, and Paris-green, applied with plaster once, sufficed to kill them. There was no blight. Rotten potatoes varied in number in the different trenches, as will be noted.

The attention of our readers is asked to the entire series of five presentations, since each should be studied with the others.

In past years the soil of our several experiment fields, as we have endeavored to show in preceding pages, needed a complete food, and nothing less would yield profitable crops. The present set of experiments may also show certain general results which are not contradictory, but in great part it will appear that a variable soil should never be selected as one fit for experiments with commercial fertilizers or with plant food of any kind whatever, except as the design may be to show its variability.

FIRST SERIES.

Average fertility of the soil as shown by no-manure trenches Nos. 6 and 15, 209.91 bushels to the acre.

Trench No. 1.—440 pounds Mapes Potato Manure.

		Bushels.
Yield, per acre.	Large tubers	298.83
Yield, per acre.	Small tubers	33.00
Total yield, per acre		331.83

No. 2.—440 pounds Mapes.
55 pounds nitrate soda.

Yield, per acre. Large tubers 236.50
Yield, per acre. Small tubers 36.66

Total yield, per acre 273.16

No. 3.—440 pounds Mapes.
110 pounds nitrate soda.

Yield, per acre. Large tubers .... 195.
Yield, per acre. Small tubers 31.16

Total yield, per acre 226.16

No. 4.—440 pounds Mapes.
220 pounds nitrate soda.

Yield, per acre. Large tubers .... 264.
Yield, per acre. Small tubers .... 22.

Total yield, per acre .... 286.

No. 5.—440 pounds Mapes.
330 pounds nitrate soda,

Yield, per acre. Large tubers 199.83
Yield, per acre. Small tubers 36.66

Total yield, per acre 236.49

No. 6.—No. fertilizer.

Yield, per acre. Large tubers 168.66
Yield, per acre. Small tubers .... 33.

Total yield, per acre 201.66

No. 7.—880 pounds Mapes.

Yield, per acre. Large tubers 185.16
Yield, per acre. Small tubers 49.50

Total yield, per acre 234.66

No. 8.—880 pounds Mapes.
55 pounds nitrate soda.

Yield, per acre. Large tubers 203.50
Yield, per acre. Small tubers 67.83

Total yield, per acre 271.33

No. 9.—880 pounds Mapes.
110 pounds nitrate soda.

Yield, per acre. Large tubers 229.16
Yield, per acre. Small tubers .... 33.

Total yield, per acre 262.16

No. 10.—880 pounds Mapes.
220 pounds nitrate soda.

Yield, per acre.	Large tubers	271.33
Yield, per acre.	Small tubers	33.
	Total yield, per acre	304.33

No. 11.—880 pounds nitrate.
55 pounds nitrate *potash*.

Yield, per acre.	Large tubers	245.66
Yield, per acre.	Small tubers	40.33
	Total yield, per acre	285.99

No, 12.—880 pounds Mapes.
110 pounds nitrate *potash*.

Yield, per acre.	Large tubers	251.16
Yield, per acre.	Small tubers	34.83
	Total yield, per acre	285.99

No. 13.—880 pounds Mapes.
220 pounds nitrate *potash*.

Yield, per acre.	Large tubers	291.50
Yield, per acre.	Small tubers	67.83
	Total yield, per acre	359.33

No. 14.—880 pounds Mapes.
440 pounds nitrate potash.

Yield, per acre.	Large tubers	320.83
Yield, per acre.	Small tubers	45.83
	Total yield, per acre	366.66

No. 15.—No fertilizer.

Yield, per acre.	Large tubers	170.50
Yield, per acre.	Small tubers	47.66
	Total yield, per acre	218.16

No. 16.—1,320 pounds Mapes.

Yield, per acre.	Large tubers	271.33
Yield, per acre.	Large tubers	49.50
	Total yield, per acre	320.83

No. 17.—1,320 pounds Mapes.
110 pounds nitrate *potash.*

Yield, per acre.	Large tubers	236.50
Yield, per acre.	Small tubers	42.16
	Total yield, per acre	278.66

No. 18.—1,320 pounds Mapes.
110 pounds nitrate soda.

Yield, per acre.	Large tubers	267.66
Yield, per acre.	Small tubers	80.66
	Total yield, per acre	348.32

No. 19.—1,320 pounds Mapes.
110 pounds *sulphate potash.*

Yield, per acre	Large tubers	262,16
Yield, per acre.	Small tubers	69.66
	Total yield, per acre	331.82

It will be seen that

No. 1.—Mapes *alone*, 440 pounds, yielded	331.83
No. 7.—Mapes *alone*, 880 pounds, yielded	234.66
No. 16.—Mapes *alone*, 1,320 pounds, yielded	320.83

Or an average of 295.77 bushels to the acre.

Taking the same amounts of Mapes with 55 pounds of nitrate of soda to the acre, and we have the following :

No. 2.—440 pounds Mapes. 55 pounds nitrate soda	273.16
No. 8.—880 pounds Mapes. 55 pounds nitrate soda	271.33
No. 18.—1,320 pounds Mapes. 110 pounds nitrate soda	348.32

Or an average of 297.60 bushels to the acre. That is to say, the addition of 55, 55 and 110 pounds of nitrate of soda to the acre to to the Mapes, did not materially increase the yield.

No. 3.—440 pounds Mapes. 110 pounds nitrate soda	226.16
No. 9.—880 pounds Mapes. 110 pounds nitrate soda	262.16
No. 18.—1,320 pounds Mapes. 110 pounds nitrate soda	278.66

Or an average of 255.66 bushels to the acre—or about 42 bushels

less than in the preceding trials, though nearly twice as much nitrogen was added.

No. 4.—440 pounds Mapes.
220 pounds nitrate of soda...................... 286.00
No. 10.—880 pounds Mapes.
220 pounds nitrate soda........................ 304.33
No. 18.—1,320 pounds Mapes.
110 pounds nitrate soda 348.32

Or an average of 312.88 bushels to the acre.

No. 5.—440 pounds Mapes, with 330 pounds of nitrate, gave a yield of only 236.49 bushels to the acre.

It appears that while 440, 880 and 1,320 pounds to the acre of the Mapes gave an average of 295.77 bushels to the acre, the addition to the above of 55, 110, 220 and 330 pounds of nitrate of soda to the acre gave but 275.66 bushels to the acre—a difference of 20 bushels against the use of additional nitrate.

Let us now compare the nitrate of soda with the nitrate of potash. Nitrate of soda contains about 16 per cent. of nitrogen; nitrate of potash (saltpeter), about 13 per cent. of nitrogen and 46 per cent. of potash. It is evident that if more potash is needed than the potato fertilizer furnishes, nitrate of potash should increase the yield more than the nitrate of soda.

No. 11.—880 pounds Mapes.
55 pounds nitrate potash 285.99
(NOTE.—Additional nitrate potash was not tried with 440 pounds of the Mapes.)
No. 12.—880 pounds Mapes.
110 pounds nitrate potash...................... 285.99
No. 13.—880 pounds Mapes.
220 pounds nitrate potash 359.33
No. 14.—880 pounds Mapes.
440 pounds nitrate potash 366.66
(NOTE.—330 pounds of nitrate of *soda* was the highest added.)
No. 17.—1,320 pounds Mapes.
110 pounds nitrate potash 278.66

Here we have an average of 315.52 bushels to the acre where nitrate of potash was used, instead of 275.66 bushels where nitrate soda was used, a difference in favor of nitrate potash over nitrate of soda of about 39 bushels per acre, and a difference in favor of additional nitrate of potash over the Mapes alone of about 19 bushels per

acre. In No. 19, 110 pounds of *sulphate* of potash was added to 1,320 pounds of the Mapes alone, the yield being 331.82 bushels to the acre, or an increase over nitrate of potash of about 16 bushels to the acre, and over nitrate of soda of about 56 bushels.

VINE GROWTH.

On June 14 the condition of the vines was estimated by three persons, 10 denoting maximum and 1 minimum vigor. The object of these estimates is, as has been explained, to show in how far such condition of the vines corresponds with the yield of tubers. It will be seen to correspond closely:

No. 1	5¾	No. 11	6¾
" 2	6	" 12	7
" 3	6¼	" 13	8¾
" 4	7¾	" 14	9¾
" 5	7	" 15	2¼
" 6	3	" 16	8
" 7	6¼	" 17	7¾
" 8	7¼	" 18	8¼
" 9	7	" 19	7¾
" 10	8		

SECOND SERIES.

Average fertility of the soil per acre of this plot, as shown by no-manure trenches Nos. 45, 54 and 59, 263.38 bushels, as against 209.91 bushels in the first series.

Trench No. 40.—440 pounds Stockbridge Potato Manure.

Yield, per acre. Large tubers	287.83
Yield, per acre. Small tubers	51.33
Total yield, per acre	339.16

No. 41.—440 pounds Stockbridge.
55 pounds nitrate soda.

Yield, per acre. Large tubers	269.50
Yield, per acre. Small tubers	51.33
Total yield, per acre	320.83

No. 42.—440 pounds Stockbridge.
110 pounds nitrate soda.

Yield, per acre. Large tubers	249.33
Yield, per acre. Small tubers	58.66
Total yield, per acre	307.99

[One rotten potato.]

No. 43.—440 pounds Stockbridge.
220 pounds nitrate soda.

Yield, per acre. Large tubers	243.83
Yield, per acre. Small tubers	80.66
Total yield, per acre	324.49

No. 44.—440 pounds Stockbridge.
330 pounds nitrate soda.

Yield, per acre. Large tubers	242.
Yield, per acre. Small tubers	69.66
Total yield, per acre	311.66

No. 45.—No manure.

Yield, per acre. Large tubers	258.50
Yield, per acre. Small tubers	62.33
Total yield, per acre	320.83

No. 46.—880 pounds Stockbridge.

Yield. per acre. Large tubers	275.
Yield, per acre. Small tubers	51.33
Total yield, per acre	326.33

No. 47.—880 pounds Stockbridge.
55 pounds nitrate soda.

Yield, per acre. Large tubers	240.16
Yield, per acre. Small tubers	47.66
Total yield, per acre	287.82

No. 48.—880 pounds Stockbridge.
110 pounds nitrate soda.

Yield, per acre. Large tubers	319.
Yield, per acre. Small tubers	55.
Total yield, per acre	374.

No. 49.—880 pounds Stockbridge.
220 pounds nitrate soda.

Yield, per acre.	Large tubers	291.50
Yield, per acre.	Small tubers	47.66
Total yield, per acre		339.16

No. 50.—880 pounds Stockbridge.
55 pounds nitrate *potash*.

Yield, per acre.	Large tubers	407.00
Yield, per acre.	Small tubers	47.75
Total yield, per acre		454.75

No. 51.—880 pounds Stockbridge.
110 pounds nitrate *potash*.

Yield, per acre.	Large tubers	289.66
Yield, per acre.	Small tubers	31.16
Total yield, per acre		320.82

(Fifteen rotten potatoes.)

No. 52.—880 pounds Stockbridge.
220 pounds nitrate *potash*.

Yield, per acre.	Large tubers	234.66
Yield, per acre.	Small tubers	42.16
Total yield, per acre		276.82

(Fourteen rotten potatoes.)

No. 53.—880 pounds Stockbridge.
440 pounds nitrate *potash*.

Yield, per acre.	Large tubers	262.16
Yield, per acre.	Small tubers	40.33
Total yield, per acre		302 49

(Two rotten potatoes.)

No. 54.—No fertilizer.

Yield, per acre.	Large tubers	146.66
Yield, per acre.	Small tubers	40.33
Total yield, per acre		186.99

(Two rotten potatoes.)

No. 55.—1,320 pounds Stockbridge.

Yield, per acre.	Large tubers	253.00
Yield, per acre.	Small tubers	42.16
Total yield, per acre		295.16

(Eleven rotten potatoes.)

No. 56.—1,320 pounds Stockbridge.
110 pounds nitrate *potash*.

Yield, per acre.	Large tubers	275.00
Yield, per acre.	Small tubers	53.16
Total yield, per acre		328.16

(Eleven rotten potatoes.)

No. 57.—1,320 pounds Stockbridge.
110 pounds nitrate soda.

Yield, per acre.	Large tubers	231.00
Yield, per acre,	Small tubers	36.66
Total yield per acre		267.66

(Twenty rotten potatoes.)

No. 58 —1,320 pounds Stockbridge.
110 pounds *sulphate potash*.

Yield, per acre.	Large tubers	324.50
Yield, per acre.	Small tubers	51.53
Total yield, per acre		376.03

(Five rotten potatoes.)

No. 59.—No fertilizer.

Yield, per acre.	Large tubers	245.66
Yield, per acre.	Small tubers	36.66
Total yield, per acre		282.32

(One rotten potato.)

It will be seen that

No. 40.—Stockbridge *alone*, 440 pounds, yielded ..339.16 bushels.
No. 46.—Stockbridge *alone*, 880 pounds, yielded ..326.33 "
No. 55.—Stockbridge *alone*, 1,320 pounds, yielded .295.16 "

Or an average of 320.21 bushels to the acre.

As in the first series, no increase of crop is given by the larger amounts of fertilizers.

The same amounts of Stockbridge, with 55 and 110 pounds of nitrate of soda added, gave the following yields :

No. 41.—440 pounds Stockbridge, 55 pounds nitrate soda, } yielded ...320.83 bushels.
No. 47.—880 pounds Stockbridge, 55 pounds nitrate soda, } yielded ...287.82 bushels.
No. 57.—1,320 pounds Stockbridge, 110 pounds nitrate soda, } yielded ...267.66 bushels.

Or an average of 292.10 bushels to the acre, or 28 bushels per acre

less than the same amounts of Stockbridge without any addition of nitrate.

No. 42.—440 pounds Stockbridge, 110 pounds nitrate soda,	yielded ...307.99 bushels.
No. 48—880 pounds Stockbridge, 110 pounds nitrate soda,	yielded ...374.00 bushels.
No. 57—1,320 pounds Stockbridge, 110 pounds nitrate soda,	yielded ...267.66 bushels.

Or an average of about 317 (316.55) bushels to the acre, or about three bushels less per acre than when the same amounts of Stockbridge were used without any addition of nitrate.

No. 43.—440 pounds Stockbridge, 220 pounds nitrate soda,	yielded ...324.49 bushels.
No. 49.—880 pounds Stockridge, 220 pounds nitrate soda,	yielded ...339.16 bushels.
No. 57.—1,320 pounds Stockbridge, 110 pounds nitrate soda,	yielded ...267.66 bushels.

Or an average of 310.44 bushels to the acre, or about 10 bushels per acre less than the same amounts of Stockbridge without any addition of nitrate.

No. 44.—440 pounds of Stockbridge and 330 pounds of nitrate gave 312 bushels to the acre, or 27 bushels less per acre than when 440 pounds of the Stockridge was used alone, as in trench No. 40, or 8 pounds less than the average of Stockbridge alone.

While 440, 880 and 1,320 pounds to the acre of the Stockbridge alone gave an average of 320 bushels to the acre, the addition to the above of 55, 110, 220 and 330 pounds of nitrate of soda to the acre gave 316.70 bushels to the acre—a loss of about three bushels to the acre, as compared with those trenches which did not receive nitrate of soda beyond that which was in the Stockbridge fertilizer.

In the first series of experiments, it will be seen that the additional nitrate added to the Mapes Potato Fertilizer reduced the yield at the rate of 20 bushels per acre.

As in the first series of which this is a duplicate, merely substituting Stockbridge for Mapes, the results of using nitrate of *potash* in place of nitrate of soda may be compared, the object being to determine whether the made-up fertilizers contain enough potash as well as nitrate.

No. 50.—880 pounds Stockbridge, 55 pounds nitrate potash.	yielded ...454.75 **bushels.**
No. 51.—880 pounds Stockbridge, 110 pounds nitrate potash,	yielded ...320.82 **bushels.**
No. 52.—880 pounds Stockbridge, 220 pounds nitrate potash,	yielded ...276.82 **bushels.**
No. 53.—880 pounds Stockbridge, 440 pounds nitrate potash,	yielded ...302.49 **bushels.**
No. 56.—1,329 pounds Stockbridge, 110 pounds nitrate potash,	yielded ...328.16 **bushels.**

The average yield from the addition of nitrate of potash was 337 bushels to the acre, an increase over the same quantities of nitrate of soda used of 21 bushels to the acre and of 17 bushels over the Stockbridge used alone. In the first series the nitrate of potash increased the yield 39 bushels per acre over nitrate of soda, and 19 bushels increase over the Mapes used alone.

In No. 58, 110 pounds of *sulphate* of potash was added to 1,320 pounds of Stockbridge, as, in trench No. 19 of the first series, the same amount of sulphate of potash was added to the Mapes. The yield was 376 bushels to the acre, or an increase over the average of nitrate of soda of 60 bushels and over the nitrate of potash of 39 bushels.

In the first series the sulphate gave an increase over nitrate of potash of 16 bushels, and over nitrate of soda of 56 bushels.

It may be worthy of consideration that in the above trials, no rotten potatoes were found in the first series. In this series, in the three trenches not fertilized but two rotten potatoes were found, while in nine of the fertilized trenches 81 rotten potatoes were found.

VINE GROWTH.

As in the first series, the condition of the vines was estimated by three persons on June 14—10 denoting the maximum and one the minimum vigor ;

No. 40	6½
No. 41	7½
No 42	8
No. 43	8¼
No. 44	8
No. 45	5¾
No. 46	7½

No. 47	
No. 48	8¼
No. 49	9½
No. 50	9
No. 51	7½
No. 52	8
No. 53	8¾
No. 54	4
No. 55	8
No. 56	8½
No. 57	8¾
No. 58	7¾
No. 59	4¾

THIRD SERIES.

Average fertility of the soil per acre of this plot as shown by no-manure trenches, Nos. 65, 74 and 79, 281.72 bushels, as against 209.91 bushels in the first series and 263.38 in the second.

Trench No. 60.—440 pounds of Bradley Potato Manure.

Yield, per acre. Large tubers	328.16
Yield, per acre. Small tubers	55
Total yield, per acre	383.16

(Three rotten potatoes.)

No. 61.—440 pounds Bradley.
55 pounds nitrate soda.

Yield, per acre. Large tubers	350.16
Yield, per acre. Small tubers	47.75
Total yield, per acre	397.91

No. 62.—440 pounds Bradley.
110 pounds nitrate soda.

Yield, per acre. Large tubers	324.50
Yield, per acre. Small tubers	62.33
Total yield, per acre	386.83

(Two rotten potatoes.)

No. 63.—440 pounds Bradley.
220 pounds nitrate soda.

Yield, per acre. Large tubers	330
Yield, per acre. Small tubers	51.33
Total yield, per acre	381.33

(Four rotten potatoes.)

No. 64.—440 pounds Bradley.
330 pounds nitrate soda.

Yield, per acre.	Large tubers	385
Yield, per acre.	Small tubers	69.66
Total yield, per acre		454.66

(Three rotten potatoes.)

No. 65.—No manure.

Yield, per acre.	Large tubers	238.33
Yield, per acre.	Small tubers	55
Total yield, per acre		293.33

No. 66.—880 pounds Bradley.

Yield, per acre.	Large tubers	320.83
Yield, per acre.	Small tubers	84.66
Total yield, per acre		405.49

(Three rotten potatoes.)

No. 67.—880 pounds Bradley.
55 pounds nitrate soda,

Yield, per acre.	Large tubers	308.
Yield, per acre.	Small tubers	80.66
Total yield, per acre		388.66

No. 68.—880 pounds Bradley.
110 pounds nitrate soda.

Yield, per acre.	Large tubers	266.71
Yield, per acre.	Small tubers	80.66
Total yield, per acre		347.37

No. 69.—880 pounds Bradley.
220 pounds nitrate soda.

Yield, per acre.	Large tubers	278.66
Yield, per acre.	Small tubers	82.50
Total yield, per acre		361.16

No. 70.—880 pounds Bradley.
55 pounds nitrate *potash*.

Yield, per acre.	Large tubers	286
Yield, per acre.	Small tubers	73.33
Total yield, per acre		359.33

No. 71.—880 pounds Bradley.
110 pounds nitrate *potash*.

Yield, per acre.	Large tubers	311.66
Yield, per acre.	Small tubers	67.83
Total yield, per acre		379.49

No. 72.—880 pounds Bradley.
220 pounds nitrate *potash*.

Yield, per acre.	Large tubers	234.66
Yield, per acre.	Small tubers	42.16
Total		276.82

No 73 —880 pounds Bradley.
440 pounds nitrate potash.

Yield, per acre.	Large tubers	311.66
Yield, per acre.	Small tubers	44
Total yield, per acre		355.66

(Two rotten potatoes.)

No. 74.—No fertilizers.

Yield, per acre.	Large tubers	247.50
Yield, per acre.	Small tubers	55.00
Total yield, per acre		302.50

No. 75.—1,320 pounds Bradley.

Yield, per acre.	Large tubers	317.16
Yield, per acre.	Small tubers	80.66
Total yield, per acre		397 82

No 76.—1,320 pounds Bradley.
110 pounds nitrate *potash*.

Yield, per acre.	Large tubers	416.16
Yield, per acre.	Small tubers	80.66
Total yield, per acre		496.82

(Four rotten potatoes.)

No. 77.—1,320 pounds Bradley.
110 pounds nitrate soda.

Yield, per acre.	Large tubers	388.66
Yield, per acre.	Small tubers	36.66
Total yield, per acre		425.32

(Thirty-one rotten potatoes.)

No. 78.—1.320 pounds Bradley.
110 pounds *sulphate potash*.

Yield, per acre.	Large tubers	287.83
Yield, per acre.	Small tubers	62.33
Total yield, per acre		350.16

(Six rotten potatoes.)

No. 79.—No fertilizer.

Yield, per acre.	Large tubers	212.66
Yield, per acre.	Small tubers	36.66
Total yield, per acre		249.32

(Twelve rotten potatoes.)

Comparing the yields of the same amount of fertilizers, one with another, as was done in Series I. and II., we shall see that—

No. 60.—Bradley *alone*, 440 pounds, yielded 383.16 bushels.
No. 66.—Bradley *alone*, 880 pounds, yielded 405.49 bushels.
No. 75.—Bradley *alone*, 1,320 pounds, yielded 397.82 bushels.

Or an average of 396.49 bushels to the acre. The increase in crop, as compared to the increase in the quantity of fertilizer, is not proportionate or profitable. In series I. and II., it may be borne in mind, the crop decreased with the increase of fertilizer.

The same amount of Bradley, with 55 and 110 pounds of nitrate of soda added, gave the following yields ;

No. 61.—440 pounds Bradley, 55 pounds nitrate soda,	yielded...397.91 bushels.
No. 67.—880 pounds Bradley, 55 pounds nitrate soda,	yielded.. 388.66 bushels.
No. 77.—1,320 pounds Bradley, 110 pounds nitrate soda,	yielded...425.32 bushels.

Or an average of 403.96 bushels to the acre, or but 7.47 bushels to the acre *more* than the same amounts of Bradley without any additional nitrate.

No. 62.—440 pounds Bradley, 110 pounds nitrate soda,	yielded...386.83 bushels.
No. 68.—880 pounds Bradley, 110 pounds nitrate soda,	yielded...347.37 bushels.
No. 77.—1,320 pounds Bradley, 110 pounds nitrate soda,	yielded...425.32 bushels.

Or an average or 386.50 bushels to the acre, or 9.99 bushels per acre less than the same amounts of Bradley used alone.

No. 63.—440 pounds Bradley, 220 pounds nitrate soda,	yielded...381.33 bushels.
No. 69.—880 pounds Bradley, 220 pounds nitrate soda,	yielded...361.16 bushels.
No. 77.—1,320 pounds Bradley, 110 pounds nitrate soda,	yielded... .25.32 bushels.

Or an average of 389.27 bushels to the acre, or 6.22 bushels per acre less than Bradley alone.

No. 64.—440 pounds Bradley and 330 pounds nitrate soda, gave 454.66 bushels to the acre, or 71.50 bushels more than when the same amount of Bradley was used without any additional nitrate.

While 440, 880 and 1,320 pounds of Bradley alone gave an average of 396.49 bushels to the acre, the addition to the above of 55, 110, 220 and 330 pounds of nitrate of soda to the acre gave an average of 394.15 bushels to the acre, or over a bushel less than the Bradley alone.

In the first series the additional nitrate reduced the yield 20 bushels per acre, in the second three bushels.

We may now, as in the first and second series, compare the results of using nitrate of *potash* in place of the nitrate of soda.

No. 70.—880 pounds Bradley, 55 pounds nitrate potash,	yielded...359.33 bushels.
No. 71.—880 pounds Bradley, 110 pounds nitrate potash,	yielded...379.49 bushels.
No. 72.—880 pounds Bradley, 220 pounds nitrate potash,	yielded...388.12 bushels.
No. 73.—880 pounds Bradley, 440 pounds nitrate potash,	yielded...355.66 bushels.
No. 76.—1,320 pounds Bradley, 110 pounds nitrate potash,	yielded...496.82 bushels.

The average yield from the addition of nitrate of potash was 395.88 bushels to the acre, or 1.73 bushel more than the nitrate of soda and 0.39 bushel over the same amounts of Bradley used alone. In the first series nitrate of potash increased the yield 39 bushels per acre over nitrate of soda and 19 bushels per acre over the Mapes used alone. In the second series the nitrate of potash increased the yield over nitrate of soda 21 bushels, and 17 bushels over the Stockbridge used alone.

In No. 78, 110 pounds of *sulphate* of potash was added to 1,320 pounds of Bradley. The yield was but 350.16 bushels to the acre, or about 25 bushels less than with either the Bradley alone, the Bradley and nitrate of soda or the Bradley and nitrate of potash.

In the first series the sulphate gave an increase over the nitrate of soda of 56 bushels and over nitrate of potash of 16 bushels. In the second series the sulphate gave an increase over nitrate of soda of 60 bushels and over nitrate of potash of 39 bushels.

The fact may again be alluded to that in the first series there were no rotten potatoes. In the second series there were 81 rotten in the fertilized trenches, and two in the "no-manure" trenches. In the

present series there are 12 in the "no-manure" trenches, and 58 in the fertilized trenches. This is a matter of little moment, however, since the fertilized trenches greatly outnumber the unfertilized.

VINE GROWTH.

As in the first and second series, the condition of the vines was estimated by three persons on June 14, 10 denoting the maximum and one the minimum of size and vigor:

No. 60........6¾	No. 67........7¾	No. 74........6
" 61........7¼	" 68........8⅛	" 75........9½
" 62........7¼	" 69........9	" 76........9½
" 63........7¾	" 70........8¾	" 77........8¾
" 64........9	" 71........9¼	" 78........8½
" 65........5¼	" 72........9¾	" 79........4¾
" 66........7½	" 73........9¼	

The largest yields, Nos. 76, 64, 77, 61, 75, 72, 62, etc., were rated respectively: 9½, 9, 8¾, 7¼, 9½, 9¾; while the lowest yields, Nos. 79, 65, 74, 68, 78, etc., were rated respectively: 4¾, 5¼, 6, 8⅛, 8½, etc. The natural fertility of the soil (in this third series) is shown by trenches Nos. 65, 74 and 79, averaging 281.72 bushels to the acre. In the first series the average fertility of the "no-manure" trenches was 209.91; in the second 263.38. Let us see how this corresponds with the average yields of the fertilized trenches:

SERIES NO. 1.	BUS.
Fertilized trenches..	294.34
Unfertilized trenches..	209.91
Yield of fertilized over uufertilized, per acre.....	84.43
SERIES NO. 2.	
Fertilized trenches..	326.66
Unfertilized trenches..	263.38
Yield of fertilized over unfertilized, per acre.....	63.28
SERIES NO. 3.	
Fertilized trenches..	391.72
Unfertilized trenches..	281 72
Yield of fertilized over unfertilized, per acre.....	110.00

For an account of the land and how it was treated, see page 832. November 28, 1891.

FOURTH SERIES.

It is reasonably claimed that better crops may be raised from fertilizers made up of different forms of each of the three essential kinds of plant food than from those made up of one form of each. That is to say, it is better to give phosphoric acid, both as superphosphate and phosphate, than either alone. So, too, as to nitrogen and potash. In this way, it is assumed, an available supply is more likely to be secured for the plant at all stages of growth. For example, if the fertilizer is supplied with nitrate of soda, sulphate of ammonia and blood, the roots will get their first nitrogen from the nitrate of soda and later from the sulphate of ammonia and blood, these being less soluble and so serving to keep up a ready diet during the entire growing season. Now, each dealer (manufacturer) of fertilizers claims a special value for his own goods owing to special treatment, combination or methods, or the superiority of the raw materials used. It might be supposed, therefore, that a combination of all these excellencies would give larger crops than the fertilizer of any single manuacturer. The following trials (96 to 103 inclusive) were designed to investigate this question:

Trench No. 96.—440 pounds of Mapes, Bradley and Stockbridge, *i. e.*, 146½ pounds of each, mixed together.

Yield, per acre.	Large potatoes	306.16
Yield, per acre.	Small potatoes	62.33
	Total yield, per acre	368.49

(Four rotten.)

No. 97.—880 pounds of the three, 293⅓ pounds of each.

Yield, per acre.	Large potatoes	276.83
Yield, per acre.	Small potatoes	84 33
	Total yield, per acre	361.16

(Two rotten.)

No, 98.—1,320 pounds of the three, *i. e.*, 440 pounds of each.

Yield, per acre.	Large potatoes	283.33
Yield, per acre.	Small potatoes	82.50
	Total yield, per acre	365.83

No. 99.—440 pounds of the three.
110 pounds nitrate soda.

Yield, per acre.	Large potatoes	251.16
Yield, per acre.	Small potatoes	51.33
Total yield, per acre		302.49

No. 100.—880 pounds of the three.
220 pounds nitrate soda.

Yield, per acre.	Large potatoes	293.33
Yield, per acre.	Small potatoes	44
Total yield, per acre		337.33

No. 101.—1,320 pounds of the three.
330 pounds nitrate soda.

Yield, per acre.	Large potatoes	320.83
Yield, per acre.	Small potatoes	42.16
Total yield, per acre		362.99

No. 102.—No fertilizer.

Yield, per acre.	Large potatoes	315.33
Yield, per acre.	Small potatoes	38.50
Total yield, per acre		353.83

(Four rotten.)

The average yield of the six fertilized trenches is at the rate of 349.71 bushels to the acre. The yield of the unfertilized trench was 353.83, or a difference in favor of "no-fertilizers" of 4.12 bushels to the acre. The average fertility of the soil, as shown by the "no-manure" trenches of the first series, was 209.91; of the second series, 263.38; of the third, 281.72, and of the fourth (present), 353.83 bushels to the acre. In the first series, the fertilized trenches yielded 84.43 bushels more than the unfertilized; in the second, 63.28 more than the unfertilized; in the third series, 110 bushels more than the unfertilized. And now in the fourth series, the *unfertilized* trench yielded 4.12 bushels more than the fertilized.

It must be considered, in partial explanation of the above showing, that the natural soil fertility increases with every series, viz.:

Series 1	209.91 bushels per acre.
Series 2	263.38 bushels per acre.
Series 3	281.72 bushels per acre.
Series 4	353.83 bushels per acre.

It will be seen, also, that the yield *per acre from the effects of the fertilizers diminishes as the natural soil fertility increases.*

The entire plot is nearly square, the four sides facing north, south, east and west. The land slopes gently, almost imperceptibly, from east to west, and from northeast to southwest. Series I. occupied the northernmost portion, II., III. and IV. following in the order given. It was thought that the soil of Series I. was the driest, as it was a trifle the highest. A ditch on the west was dug three years ago (as already stated) to carry away the surface water, which in previous years was held in a shallow basin, towards the west and southwest.

VINE GROWTH.

The condition of the vines was estimated as follows:

No. 96........7⅝	No. 99.......7½	No. 101.......9⅜
" 97 ....8¼	" 100.......8⅞	" 102.......4¾
" 98........9⅛		

FIFTH SERIES—(Last).

The results of using Mapes, Bowker and Bradley fertilizers separately and together, with and without added nitrogen in the form of nitrate of soda and nitrogen, and potash in the form of nitrate of potash, are before the reader. In this fifth (and last) series of experiments the effects (1) of snuff are to be recorded and (2) the effects of nitrogen, phosphate and potash, used separately and in various combinations.

Trench No. 20.—No fertilizer.

Yield, per acre. Large potatoes....................	168.66
Yield, per acre. Small potatoes....................	60.50
Total yield, per acre..........................	229.16

No. 21.—1,760 pounds tobacco snuff.

Yield, per acre, Large potatoes....................	185.16
Yield, per acre. Small potatoes....................	42.16
Total yield, per acre..........................	227.32

No. 22.—3,520 pounds snuff.

Yield, per acre. Large potatoes....................	278.66
Yield, per acre. Small potatoes....................	56.83
Total yield, per acre..........................	335.49

No. 23.—3,520 pounds snuff.
440 pounds nitrate soda.

Yield, per acre.	Large potatoes	300.66
Yield, per acre.	Small potatoes	40.33
	Total yield, per acre	340.99

No. 24.—3,520 pounds snuff.
440 pounds nitrate *potash.*

Yield, per acre.	Large tubers	394.16
Yield, per acre.	Small tubers	29.33
	Total yield, per acre	423.49

No. 25.—55 pounds nitrate *potash.*

Yield, per acre.	Large potatoes	311.66
Yield, per acre.	Small potatoes	33.00
	Total yield, per acre	344.66

No. 26.—110 pounds nitrate *potash.*

Yield, per acre.	Large potatoes	196.16
Yield, per acre.	Small potatoes	42.16
	Total yield, per acre	238.32

No. 27.—220 pounds nitrate *potash.*

Yield, per acre.	Large potatoes	209.00
Yield, per acre.	Small potatoes	33.00
	Total yield, per acre	242 00

No. 28.—440 pounds nitrate *potash.*

Yield, per acre.	Large potatoes	225.55
Yield, per acre.	Small potatoes	27.50
	Total yield, per acre	253.05

No. 29.—880 pounds nitrate *potash.*

Yield, per acre.	Large potatoes	227.00
Yield, per acre.	Small potatoes	27.50
	Total yield, per acre	254.50

No. 30.— 55 pounds nitrate soda.
220 pounds dissolved bone.

Yield, per acre.	Large potatoes	203.50
Yield, per acre.	Small potatoes	44.00
	Total yield, per acre	247.50

No. 31.— 55 pounds nitrate *potash.*
220 pounds dissolved bone.

Yield, per acre.	Large potatoes	177.83
Yield, per acre.	Small potatoes	47.06
Total yield, per acre		224.89

No. 32.— 55 pounds nitrate *potash.*
220 pounds fine raw bone.

Yield, per acre.	Large potatoes	165.00
Yield, per acre.	Small potatoes	55.00
Total yield, per acre		220.00

No. 33.— 55 pounds nitrate soda.
220 pounds fine raw bone.

Yield, per acre.	Large potatoes	234.66
Yield, per acre.	Small potatoes	40.33
Total yield, per acre		274 99

No. 34.—*No fertilizer.*

Yield, per acre.	Large potatoes	258.50
Yield, per acre.	Small potatoes	33.00
Total yield, per acre		291 50

No. 35.—55 pounds nitrate soda.

Yield, per acre.	Large potatoes	245.66
Yield, per acre.	Small potatoes	58.66
Total yield, per acre		304 32

No 36.—110 pounds nitrate soda.

Yield, per acre.	Large potatoes	264.00
Yield, per acre.	Small potatoes	55.00
Total yield, per acre		319.00

No. 37.—220 pounds nitrate soda.

Yield, per acre.	Large potatoes	266.71
Yield, per acre.	Small potatoes	44.00
Total yield, per acre		310.71

No. 38.—440 pounds nitrate soda.

Yield, per acre.	Large potatoes	280 50
Yield, per acre.	Small potatoes	55 00
Total yield, per acre		335.50

No. 39.—880 pounds nitrate soda.

Yield, per acre. Large potatoes 238.33
Yield, per acre. Small potatoes 31 16

Total yield, per acre 269 49

No. 80.—220 pounds nitrate soda. (Same as No. 37.)

Yield, per acre. Large potatoes 293.33
Yield, per acre. Small potatoes 36.66

Total yield, per acre 329 99

(Fifteen rotten potatoes.)

No. 81.—220 pounds nitrate *potash*.
(Same as No. 27.)

Yield, per acre. Large potatoes 300 66
Yield, per acre. Small potatoes 47.66

Total yield, per acre 348.32

(Eighteen rotten potatoes.)

No. 82.—110 pounds nitrate soda.
110 pounds nitrate *potash*.

Yield, per acre. Large potatoes 313.50
Yield, per acre. Small potatoes 45.83

Total yield, per acre 359.33

(Eight rotten potatoes.)

No. 83.—110 pounds nitrate soda.
110 pounds *sulphate potash*.

Yield, per acre. Large potatoes 287.83
Yield, per acre. Small potatoes 62,33

Total yield, per acre 350.16

(Nine rotten potatoes.)

No. 84.—110 pounds nitrate *potash*.
110 pounds *sulphate* potash.

Yield, per acre. Large potatoes 300.66
Yield, per acre. Small potatoes 49.50

Total yield, per acre 350.16

(Twenty-eight rotten potatoes.)

No. 85.—110 pounds nitrate soda.
220 pounds raw bone flour.

Yield, per acre.	Large potatoes	300.66
Yield, per acre.	Small potatoes	62.33
Total yield, per acre		362.99

(Fifteen rotten potatoes.)

No. 86.—110 pounds nitrate *potash*.
110 pounds raw bone.
110 pounds dissolved bone.

Yield, per acre.	Large potatoes	313.50
Yield, per acre.	Small potatoes	77.00
Total yield, per acre		390.50

(Nine rotten potatoes.)

No. 87.—110 pounds nitrate soda.
110 pounds sulphate *potash*.
110 pounds dissolved bone.
110 pounds raw bone.

Yield, per acre.	Large potatoes	333.66
Yield, per acre.	Small potatoes	62.33
Total yield, per acre		395.99

(Nine rotten potatoes.)

No. 88 —110 pounds sulphate *potash*.
110 pounds nitrate *potash*.

Yield per acre.	Large potatoes	271.33
Yield, per acre.	Small potatoes	71.50
Total yield, per acre		342.83

(See No. 84.)

(Nine rotten potatoes.)

No. 89.—110 pounds sulphate *potash*.
110 pounds nitrate soda.
(See No. 83.)

Yield, per acre.	Large potatoes	315.33
Yield, per acre.	Small potatoes	40.33
Total yield, per acre		355.66

(Three rotten potatoes.)

No. 90.—220 pounds sulphate *potash*.
220 pounds nitrate *potash*.

Yield, per acre.	Large potatoes	324.50
Yield, per acre.	Small potatoes	51.33
Total yield, per acre		375.83

(Six rotten potatoes.)

No. 91.—220 pounds sulphate *potash*.
220 pounds nitrate soda.

Yield, per acre.	Large potatoes	353.83
Yield, per acre.	Small potatoes	60.50
Total yield, per acre		414.33

(Seven rotten potatoes.)

No. 92.—*No fertilizer*.

Yield, per acre.	Large potatoes	293.33
Yield, per acre.	Small potatoes	40.33
Total yield, per acre		333.66

(Three rotten potatoes.)

No. 93.—440 pounds sulphate *potash*.
440 pounds nitrate *potash*.

Yield, per acre.	Large potatoes	315.33
Yield, per acre.	Small potatoes	56.83
Total yield, per acre		372.16

(Two rotten potatoes.)

No. 94.—440 pounds nitrate soda.
(Compare with No. 38.)

Yield, per acre.	Large potatoes	306.16
Yield, per acre.	Small potatoes	66.00
Total yield, per acre		372.16

(Two rotten potatoes.)

No. 95.—440 pounds nitrate *potash*.
440 pounds nitrate soda.
440 pounds sulphate *potash*.

Yield, per acre.	Large potatoes	355.66
Yield, per acre.	Small potatoes	29.33
Total yield, per acre		384.99

Contrary to expectation, there was not a rotten potato in this trench. It is noteworthy also that the average size of tubers was the largest, with the fewest small ones.

VINE GROWTH.

As in the previous series, the condition of the vines was estimated on June 14, 10 denoting the maximum and one the minimum of size and vigor :

No. 21........3¾	No. 33........6½	No. 85........6
" 22........6	" 34........5	" 86........7
" 23........5¾	" 35........5⅛	" 87........7⅛
" 24........5⅞	" 36........5¾	" 88........5⅞
" 25........5⅞	" 37........6	" 89........5⅞
" 26........6	" 38........7½	" 90........6
" 27........6½	" 39........5¼	" 91........6¾
" 28........7	" 80........5¾	" 92........5¾
" 29........6¼	" 81........6	" 93........6½
" 30........6	" 82........6	" 94........6⅞
" 31........6⅛	" 83........6	" 95........7
" 32........6¼	" 84........6½	

In this series the average product of the unfertilized trenches, Nos 20, 34 and 92, was 284.77 bushels to the acre. The position of the trenches from Nos. 20 to 39 was next to the highest land (Mapes); the position of the rest, Nos. 80 to 95, was nearly the lowest. No. 20 (no fertilizer) yielded 229 bushels ; No. 34, 291 bushels, and No. 92. 333 bushels, the yield generally increasing as the land declined, whether the trenches were fertilized or not. Now, let us compare the average yield of the trenches of the higher land (Nos. 20 to 39) with the average yield of the trenches of the lower land (Nos. 80 to 95, inclusive). The average yield of trenches from Nos. 20 to 39, inclusive (higher land), was at the rate of 284 bushels to the acre. The average yield of trenches from Nos. 80 to 95, inclusive (lower land), was at the rate of 368 bushels to the acre, an increase of 84 bushels to the acre for the lower and (supposably) moister land.

When we began to write up the results of this laborious series of potato experiments, we were fearful that they would prove contradictory and worthless. The known variability of the land did not at all account for the gradual increase in the crop as we proceeded from the

northeast (higher land) to the southwest (lower land), because the grading had been done in such a way that, though marked differences in yield were to have been looked for as between two contiguous trenches, yet in a breast of 25 trenches, the average yield ought not to have been materially affected by the grading, since the same soil was used—some little parts (dishes) receiving more than other parts, some (hillocks) receiving less or none.

The increasing yield as we go from northeast to southwest is not however, altogether attributable, it may be assumed, to a proportionate declination of the land. A careful examination shows that the subsoil of the northeastern portion is more sandy, and that 30 feet further north it runs into a pure, seemingly bottomless sand; while as we go to the south the subsoil becomes hard, and at a depth of three feet almost impenetrable. It is plain, then, that if the entire plot *were level*, the soil would retain moisture more and more as we go toward the southwest. It must not be forgotten that the season was the driest of many years. The reader may argue that in the moister portions of the plot, the *fertilizers* ought to have given larger yields, or a greater difference between the fertilized and unfertilized trenches. It is not difficult to understand, however, that while an exceedingly small quantity of soil moisture might *support* the plant, it might yet be insufficient to *dissolve* the applied chemicals and render them fit for food.

AVERAGES.

The seven nitrate of soda trenches yielded an average of 320.18 bushels to the acre; the six nitrate of potash trenches an average of but 280.14 bushels to the acre—a difference in favor of the nitrate of soda of about 40 bushels per acre. But the nitrate of soda trenches were Nos. 35, 36, 37, 38, 39, 80, 94, while the nitrate of potash trenches were further towards the northeast which, we are assuming, is less retentive of moisture than the trenches toward the southwest. The nitrate of potash trenches were Nos. 25, 26, 27, 28, 29 and 81. If we compare nitrate of potash trench No. 81 with nitrate of soda trench No. 80 (which were side by side), we shall see that the nitrate of potash outyielded the nitrate of soda by 18.33 bushels per acre. Trench No. 94, which received 440 pounds of nitrate of soda (twice as much as No. 81, which received 220 pounds of nitrate of *potash*)

yielded 372.16 bushels, or 23.80 bushels more than the nitrate of potash, but its position was 13 trenches nearer the lowest (or southwestern) portion of the field. The interested reader may readily make further comparisons for himself, if he will but bear in mind that the first breast of trenches begins with No. 1 and ends with the last tobacco trench, No. 24; and that this is the highest and driest land, growing moister from No. 1 to 24, or from east to west.

As we further go to the south the trenches progress regularly in number up to the last, No. 102, which occupied the lowest part, the southwestern boundary of the entire plot. The whole difference, however, between the highest (northeast) part and the lowest (southwest) part is not over 18 inches.

It may be noted that the potatoes fertilized with snuff were brighter and smoother than the others. As there was no scab, it could not be ascertained if the snuff acted to prevent it.

The number of what we considered large or marketable potatoes to a bushel of 60 pounds was 279.

The Rural Blush, as in the preceding experiments of these kinds, was the potato used.

The above series of fertilizer experiments fairly point to one conclusion, if to no other, viz., that the drought may be such that while there is insufficient moisture in the soil to dissolve chemical fertilizers and render them soluble, there may still be soil moisture enough to give a certain amount of nutriment to the plants. There is no such thing as plant growth without moisture; but it is easy to see, as we have said, that an amount of moisture sufficient to keep the plant alive and growing might be quite insufficient to dissolve applied potash, nitrate or phosphate. It is quite within the experience of many of our readers that farm manure—even when applied in generous quantity—has failed to give a large crop. In such cases, the failure is usually and justly attributed to the season. When fertilizers are used freely and the crop fails during a dry season, many are too apt to attribute the failure to the fertilizers and not to the drought.

CHAPTER XVIII.

Another talk about the use and effects of chemical fertilizers. Benefits of the Bordeaux mixture diluted.

On page 128 several talks between farmers and the writer are placed before the reader. Since the first edition appeared, other farmers have visited us, and the following questions and answers embody such portions of our talks regarding potatoes as have not been well emphasized in other portions of this book :

QUESTION. You have been experimenting with potatoes for 15 years or more. As a consequence, do you feel competent to instruct your average potato-growing neighbor ?

ANSWER. Yes, of late years our regular crop has far exceeded the crops of our neighbors.

Q. With a proportionate increase in the cost of production ?

A. With *less* than a proportionate increase in the cost of production.

Q. What new experiments do you propose to try this season ?

A. None.

Q. How is that ?

A. We have tried all the rational (and many irrational) experiments we could think of, again and again, and there seems to be no reason for continuing them further.

Q. You fancy, then, that you "know it all ?"

A. We fancy that we do not know what further experiments to make with a view to a further economical increase of crop.

Q. For your soil or for all soils ?

A. Among the results of our experiments, it has been found that different soils require different treatment.

Q. In all respects ?

A. No, in minor respects.

Q. Then in all essential respects, you think you know how to produce a maximum crop of potatoes at a minimum cost?

A. With the present data for investigation, yes.

Q. That is saying a good deal?

A. It is simply saying that we have tried every method of culture we can think or hear of, often enough to have received what we believe to be trustworthy answers to the questions asked. It is perhaps more a matter of belief than of absolute proof.

Q. To what do you attribute the fact that your crops are much larger than those of your neighbors?

A. To the fact that they do not fit their land properly, and are unwilling to use suitable fertilizers in sufficient quantity.

Q. And wherein is their fittting inadequate?

A. The surface soil alone is properly fitted.

Q. Hence it is you favor your trench system?

A. Yes. That helps to fit the soil to a depth of six inches or more, the same as the surface soil is fitted by harrowing. It is more important that the soil in which the tubers and roots form and grow should be mellow and uniform than that the surface soil, in which they do *not* grow, should be so prepared.

Q. Do you prefer fertilizers to farm manure?

A. Yes, for the one reason that farmers cannot afford, or think they cannot, to use farm manure in sufficient quantity to supply the needs of the potato during every stage of its growth. A maximum crop of potatoes means an *ample* supply of potato food, and this means a richer soil than one farmer in 100 has.

Q. And do you think an ample supply of fertilizers can be furnished at a less cost with the same effect?

A. It can be supplied at a less cost for this year and next, and perhaps a third or fourth. Of two soils equally rich—one with fertilizer, the other with manure—we should much prefer the latter.

Q. Why?

A. Because it exists in an equally soluble and less caustic form.

Q. What do you mean by "caustic?"

A. Comparing grape wine and grape brandy, the latter is the more caustic form of liquor.

Q. Do you regard fertilizers, then, as stimulants?

A. Not at all in the usual sense of the word. All foods in a condensed form become stimulants—many nutritious foods become poisons if sufficiently concentrated.

Q. Why do not farmers use fertilizers in sufficient quantity upon potatoes?

A. For several reasons. The cost is startling. Again, many farmers use inferior fertilizers because the price is low, which means either that the fertilizer is low in soluble plant food, or that the food exists in a form regarded by the plant as "*persona non grata.*" Farmers can not know just what fertilizers will give them maximum crops until they have learnt by experiment. Potatoes, as other plants, must be supplied with an abundance of suitable food. If the soil is deficient in potash and rich in phosphate and nitrogen, then an ample supply of potash renders the soil productive to its fullest capacity. If, however, this farmer buys an "ammoniated superphosphate," and finds that it does not increase the crop, he must not assume that all fertilizers are frauds, as many farmers do.

Q. You emphasize the importance of a *sufficient* supply of fertilizer. What amount do you consider a sufficient quantity?

A. That depends wholly upon the fertility of the soil. Upon our experiment land, impoverished by many years of cropping with little or no manure, we have found that 1,750 pounds to the acre of a high-grade potato fertilizer could be economically used.

Q. What size of potato seed have you found it advantageous to use, and how deep should the seed be placed, and how far apart?

A. The size of seed depends upon the size of the tuber and the number of eyes. The fewer the eyes to a tuber, the larger the pieces may be. We use from two to three vigorous eyes, with all the flesh possible. In our loamy soil, planting in trenches four to five inches is about the right depth. The distance apart also depends upon the variety used. Theoretically, potatoes should be planted so far apart as to admit of a full natural development of the tops. Early Ohio may, therefore, be planted closer than Beauty of Hebron or White Elephant.

Q. Have your experiments taught you how to produce maximum crops in a droughty season?

A. No, that could be done only by irrigation. But we have found

that our method insures protection against drought to a certain extent. Our experiments have shown again and again that the finest tops, as a rule, give the largest yield of tubers. Any system of treatment, therefore, which increases the growth above ground may be trusted to increase the growth beneath. The trench conserves moisture, and this moisture retains the fertilizer or food in a soluble form *longer* than when it is applied in the usual way, that is, "in the hill," or sown broadcast. Vigorous tops mean a vigorous root system, and vigorous roots penetrate the soil further and deeper in all directions than the feebler root system of smaller tops. As the root system increases, so do the tuber-bearing stems increase.

Q. Is the quality of potatoes influenced by the manure used ?

A. The work done here has never been designed to answer that question. From careful experiments carried on at the New Jersey Experiment Station, the answer would be emphatically "yes." It was found that both manure and fertilizer increase the water content of the tuber; that the *form* of potash used influences both the water and starch contents, kainit giving the most water and least starch; next came yard manure, muriate and, finally, sulphate of potash, the last giving the highest content of starch excepting only the tubers raised without manure of any kind. As to *quality*, the difference in flavor was marked. Those raised with sulphate were decidedly superior to all others; those from yard manure next, from the muriate next and, finally, those from the kainit ranked lowest. As to *yield*, muriate stood first, sulphate next, kainit next and yard manure last.

Q. Have you derived any benefit from spraying with the Bordeaux mixture ?

A. Not from the Bordeaux mixture of the original recipe. It injured the vines and decreased the yield; but from a greatly diluted Bordeaux mixture, unmistakable benefits were derived. A plot of 33 feet square was selected for the trial. Half was sprayed three times during the season—in June, July and August—the other half not sprayed. The vines of the latter were somewhat injured by blight, and died ten days earlier than the sprayed half, which was not touched by blight,

Q. What formula did you use ?

A. The simple formula of one ounce each of copper sulphate and quick lime to every gallon of water.

Q. Did you use Paris-green separately?

A. No, with the Bordeaux. One level teaspoonful of Paris-green was stirred in every pail (two gallons) of water.

Q. How did you apply the mixture?

A. With a hand "aquapult" pump, using a rubber tube 10 feet long and a Vermorel or Cyclone nozzle. We preferred the former, because it is readily freed of any obstruction.

CHAPTER XIX.

Brevities. The objections to hilling up. Mr. Hirsey answered. Difficulty in crossing potatoes. So-called hybrid seeds are not hybrids. Hybrids between the strawberry tomato and the potato. Prof. Bailey's grafting experiments. Why plaster is, sometimes effective, sometimes not. Questions answered.

WE cannot in these days afford to plant potatoes with deep eyes, either for home use or market.

IT would be but little trouble to save out the best tubers of the most productive hills while digging the crop; and if by so doing we can preserve the original vigor of the varieties, the trouble will be well expended.

WE find that there are 673 potatoes of average size in a barrel. If the potato pieces are planted in drills one foot apart, the drills being three feet apart, 14,520 will be required for an acre, or about 4½ barrels, if we make five pieces of each potato.

WHAT does the farmer hill up for? Some do it to kill the weeds. Others hill up to increase the crop. This may increase the yield, but it also increases the proportion of small potatoes. The green stems, covered up by hilling, send out roots and tuber-bearing stems from joints or adventitious buds. The hill accomplishes only what the trench accomplishes far better, by giving a depth of soil below, instead of above, and a more uniform pressure on all sides to be overcome by the rapidly growing tuber.

THE practice of hilling up corn and potatoes is not only robbing Peter to pay Paul, but is worse than that. It is both robbing Peter

and injuring Paul. When corn is a foot high, the roots extend a foot on either side; *i. e.*, the plant is the center of a circle of roots at least two feet in diameter. Now, in order to hill up, we take away the soil from these root extremities to heap it about the stems where it is not needed for any purpose whatever. When the roots extend half-way or more between the hills or drills, it is worse. The roots are then in a measure deprived of moisture, food and shelter, while many of the roots which the plant needs are severed.

THE true seeds of potatoes will germinate if three years old.

BE careful not to plant frost-bitten seed potatoes.

AVOID ploughing potato land when it is not dry enough to crumble as it is plowed.

IT is a good plan, for late potatoes, to sow blood, nitrate of soda or sulphate of ammonia not until the sprouts show themselves above the ground.

CULTIVATE shallow if you would avoid the worst effects of dry weather.

MR. EDMUND HIRSEY, of Massachusetts, has carried on a series of experiments with potatoes for several years. He arrives at some conclusions which are at a variance with the results of my own experiments. "The form of a potato," he says, "cannot as a rule be changed by the selection of any particular form." This may be true of well established varieties, but it is not true as to the selection of the tubers which true seed produces. We have repeatedly selected differently shaped potatoes produced by the seedling plant, establishing varieties widely differing from each other in shape. (See Chap. XV.)

Again he says: "The seed-end of a potato is better to plant than the stem end, because the plants start with more vigor and produce larger and more potatoes." Yes, the seed end does start earlier and more vigorously than the stem-end. It is true also that seed-end pieces will produce more potatoes than stem-end pieces—but they are smaller. The greater the number of eyes planted, the greater the number of sprouts and, consequently, the more potatoes are formed. But they are necessarily smaller. He further says that "two distinct varieties will not mix in the hill." This is a postulate and scarcely needs to be stated. There will always be farmers who

believe that potatoes do mix in the hill, as well as farmers who believe that wheat changes to chess, oats to barley, etc. But until absolute proof of such changes has been furnished, we must be guided by what we know of the laws of plant growth.

I HAVE never been able to cross potato flowers, for the reason that in spite of diligent search I have never been able to gather any pollen, though no less than an average of 100 different varieties have been raised in small quantity every season. And yet, some of our seedsmen offer "hybrid potato seed" for 25 cents the packet. In the technical sense, there is no such thing as "hybrid" potato seed. If we were to cross a tomato or an alkekengi and a potato, the seed would then be true hybrids. But crosses between different kinds of potatoes produce cross-breeds merely, and it is a more correct word to use. Hundreds of new seedlings are announced from year to year, with both parents given in a positive way. We may reasonably believe that the parentage of many of our new potatoes, and the hybridizing of these "hybrid" seeds, are merely guessed at or are altogether fictitious. Of course, "seed balls" do form, and in such cases there must be pollen. But to find pollen and to apply it so that a cross is *known* to have taken place, is a task that no one can afford to do, unless, in place of 25 cents a packet, he were to charge 50 cents or more per *seed.*

SPEAKING of "hybrid" potatoes, the following bit of experience may interest the reader. An attempt was first made to cross the tomato upon the potato. This failed. Pollen from the alkekengi, or strawberry tomato, was then applied to the pistils of the potato flower, and one seed ball was the result. The several seeds were planted, four of which sprouted and grew. The plants resembled potatoes in all ways save two; they did not blossom, and in the fall it was found, upon digging them up carefully, that not a tuber, nor the sign of one, had formed.

In this connection, the results of grafting potato cions upon tomato stems, and *vice versa*, as effected by Prof. L. H. Bailey, of Cornell University, during the past season, may be mentioned. The potato plants with tomato tops produced good tubers even when no potato sprouts were allowed to grow from the root. The tomato tops in some cases produced good, large tomatoes also—two diverse crops

from one plant. But the one which produced most tomatoes bore no potatoes—the vigor had evidently all gone to the tomato fruits. The tomato plants with potato tops grew nicely, but produced no tubers. But the potato tops blossomed freely, but no balls set.

IN places where good wood ashes are cheap, farmers should never buy chemical fertilizers until the ashes have been tried. A first-rate supplement to unleached ashes is fine raw-bone flour, being strong in phosphoric acid, in which ashes are weak, and furnishing nitrogen, of which ashes are destitute.

THROUGH all times plaster has been regarded by many as a direct and very valuable plant-food, especially for clover. By others it has been regarded as of no value, for the good reason that no visible effects followed its use. In the light of more recent knowledge, such contradictory phenomena are apparently well explained. Plaster sets the fixed or insoluble potash of the soil free. That is to say, the sulphuric acid of the plaster combines with the fixed potash of the soil, forming sulphate of potash, which is soluble. So, too, it may act upon the carbonate of ammonia of the soil, which is volatile, fixing it as sulphate of ammonia, until as such it is used by the growing crop or passes through the soil in the drainage water. In most cases, it is probable that the lime of the gypsum has little, if any, effect in increasing the crop upon soils which are already supplied with lime, and yet it is often upon just such soils that gypsum shows at its best. In such soils there is little doubt that potash, either in unleached ashes, muriate or sulphate of potash, would have a more immediate and telling effect upon the crop. In this case the needed element (potash) is given to the soil in a soluble condition; in the other, the plaster splits into two parts, so to say, the lime becoming fixed and the sulphuric acid seizing upon the inert potash, rendering it soluble. It will be seen that plaster is therefore what may fairly be called a stimulant—an excitant. How greatly soever it may increase the crop one season, we may look for a proportionate decline the next.

THE KILLING OF POTATO TOPS LESSENS THE YIELD.

D. F. S. HENDERSON, Texas.—Does the killing of potato tops by late spring frosts diminish the yield or deteriorate the quality of the crop? We plant potatoes about February 15, and the tops are fre-

quently killed by frosts. We get a crop, of course, but is'nt it smaller than it would have been had not the frosts killed the tops ?

Answer.—There can be little doubt that the killing of potato tops by frost or any other cause lessens the yield materially and also impairs the quality of the tuber. If the tops were killed a second time by the frost, what would be the effect ? It is true that potatoes may be raised from cuttings continuously. The cut tuber used for seed is itself a cutting. But the cutting must be a strong, healthy cutting. A plant injured by frost is weakened in every part.

FERTILIZING POTATOES.

C. J. M., Tom's River, N. J.—In the Rural trench system the fertilizer is applied above and below the "seed." Do you in general favor "hill and drill" or broadcast fertilizing? Am I wrong in broadcasting valuable (costly) fertilizers, that is, do I fail to get the most profitable immediate returns ?

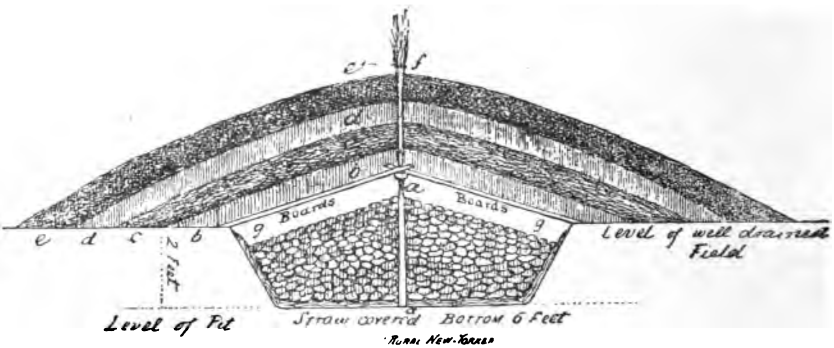
Answer.—Above or below or both as one chooses. I have, as a rule, favored broadcast fertilizing. For potatoes I favor confining the fertilizers to *the trenches* if one foot or more wide. This is an opinion *not* founded on experiment. For corn, wheat and all crops the roots of which extend from row to row and plant to plant, we have no doubt that broadcast fertilizing is the most economical thing to do. We find that the *mass* of roots of potatoes grow in the trenches and that, therefore, if the trenches are three feet apart, they will get at least twice as much fertilizer as if the same gross amount were distributed broadcast.

KEEPING POTATOES.

W. O. F., Greensburg, Ind.—What is the best plan for keeping potatoes over winter, especially early potatoes for seed ?

Answer.—In northern sections the commonest way is to store the tubers in cool, well ventilated cellars. Opinions vary as to whether the potatoes should be packed in large bins or in smaller lots in barrels or boxes, but it would seem that most growers store in large masses. It pays, as all agree, to shovel or handle the seed potatoes over several times during the winter. We have often thought that potatoes could be stored very successfully in sacks, which could be emptied and refilled once each month, or six weeks, during the winter.

Many of the large growers use pits for storing. The pit illustrated at Fig. 15 is described by W. W. Tracy, of Detroit. The potatoes are put into the pit as soon after being dug as possible, when they are covered with straw or corn stalks for a few days. They are then covered with boards and earth, the ends of the pit being left open. Later the ends are closed, and a small amount of ventilation is afforded by means of a wisp of straw, which extends up through the center of the covering to the open air. In the illustration, *a* represents a pole supporting the boards ; *b*, six inches of earth ; *c*, eight inches of manure ; *d*, six inches of earth ; *e*, eight inches of manure ; *f*, a straw ventilator, and g, a space of eight inches between potatoes and boards.



A Potato Pit. Fig. 15.

LARGEST YIELDERS.

E. P. N., Albany, N. Y.—What varieties would you select, as likely to give the greatest number of bushels to the acre ?

Answer.—Silver Lake, Everett, Summit, Jewell, Columbia, Charter Oak, Morning Star, Early Gem, Snowflake, Late Vermont, White Elephant, or late Beauty of Hebron, White Star, Burbank, Empire State, Home Comfort, Early Maine, Cream of the Field, Dakota Red, R. N.-Y. No. 2, Brownell's Winner, Corliss's Matchless, Bonanza, Late Hoosier, Montreal, Green Mountain, Hodgman's Seedling, Nott's Victor, Pearl of Savoy, Early Puritan, Rural Blush, Minister, Tonhosks, Crown Jewel, Polaris, Delaware. Not all of these

are of good quality, as grown at the Rural Grounds, but the quality may be good in other soils.

ABOUT POTATO PLANTING.

J. H. N., Afton, N. Y.—I am going to plant about 14 acres of potatoes on a sandy loam upland. The White Star and Burbank are the kinds mostly raised in this section; would you advise me to plant those or some other varieties, and what kind would you advise? 2. How many bushels shall I allow to the acre, and if cut, how many eyes to the hill? 3. Would wood ashes be good as a fertilizer?

Answer.—1. It will be safer on large areas to plant potatoes that you know do well on other farms near you, than to try experiments. New varieties ought always to be tried on small areas. 2. If you cut medium sized potatoes, having a medium number of eyes, to two eyes, and plant one by three feet apart, you will need 12 to 15 bushels. Not less than two strong eyes. Give all the flesh possible. 3. Yes, a splendid fertilizer, but one-sided. On your land, add fine raw-bone flour—400 pounds to the acre.

HOW MUCH SEED POTATOES.

J. V. C., Lysander, N. Y.—In planting potatoes for flat culture, how many bushels of seed are needed per acre?

Answer.—The above question cannot be answered definitely. All depends upon the size of the potato, the number of eyes to be planted, the number of eyes in the variety of potato and the distance apart. The best way to find out is to count the potatoes in a barrel, and multiply the number by the number of pieces each potato will give. Then estimate the distance apart at which it is proposed to plant. If to be planted one by three feet apart, 14,520 pieces will be required for an acre.

W. G. S., Benedict, N. Y.—1. Why have we no potato balls now? Is it on account of the Colorado beetle? 2. How do potatoes "mix" in the hill?

Answer.—1. It seems to be a law of nature that as we change plants to our needs or "improve" them as we may, they deteriorate in other ways. Thus double flowers are produced at the cost of stamens and pistils. Many fruits—apples, pears, oranges for example

—as they are increased in size become seedless. We grow potatoes for the tubers, and the plants having been propagated by tubers through generations, their nature is changed. We produce larger tubers and more of them. The energy of the plants, which generations ago was divided between tubers and seed balls, is now directed towards tubers entirely. 2. Potatoes do not "mix" in the hill. It is impossible. Any variation in potatoes that appears in the product of the same seed potato, is owing to bud variation—just the same as any green-leaved plant is liable to produce a colored-leaved shoot. These are called "sports" for want of a better word. It seems probable, that "sports" are really the cropping out of foreign blood or owing to natural or artificial crossing or hybridization, the effects of which, though dormant for years, finally become potent through peculiar conditions.

HIGH AND LOW-GRADE FERTILIZERS.

An Old Farmer, Monroe County, N. Y.—In *The Rural* of October 25, mention is made of "low-grade" and "high-grade" fertilizers. I would esteem it a favor if you would tell me what I am to understand by these terms. Does the high-grade contain something that the low-grade does not contain, or is there more of some valuable ingredient in the high-grade than in the low-grade, and if so, what is it? Or is the difference due to the quality, or solubility, or availability of the ingredients? Please give us an illustration of a high and low-grade article, telling just what each contains, and the value and cost of each. I believe you are right, but many of my neighbors prefer the low-priced fertilizers. Some of them are using dissolved South Carolina rock phosphate, and say that it produces just as good results as the higher-priced article. But perhaps they are not using what you term a "high-grade" fertilizer.

Answer.—Here is a forcible question—from an experienced farmer, too, "Why use a high-grade fertilizer?" Because (1) it costs no more than a low-grade for freight. Because (2) it costs no more to spread it on your land. Because (3) it costs the firm that mixes it no more than to mix a low-grade. Because (4) the per cent. of plant-food ingredients is (as a rule) higher in high-grades than in low-grades.

HOME-MIXED FERTILIZERS.

C. S. A., Lansing, Mich.—Does it pay to buy the chemicals and mix them at home ?*

Answer.—Yes and no. Nothing pays that is not managed with intelligence. It is better to buy of a reputable firm, at a fair price, a standard brand of fertilizer than to buy a lot of coarse chemicals and nitrogenous waste and to mix them hap-hazard. It is probably cheaper in the rush of spring work to buy factory-mixed goods than to stop to order chemicals in small quantities and to mix them. In some places, and at exceptional times, factory-mixed goods may be sold at prices so low as to make it altogether more profitable to buy them than to buy and mix fertilizer chemicals.

On the other hand, many farmers find it much to their advantage to buy for cash the same fertilizer chemicals that are bought by manufacturers, and to mix them for themselves, instead of buying for cash the factory-mixed goods.

WHAT ARE THE ADVANTAGES CLAIMED FOR HOME-MIXING?

a. It is easier to prove the quality of separate chemicals than of the mixture of them. It is said that it is quite beyond the chemist's power to certainly detect inferior forms of nitrogen, for instance, in a mixed fertilizer, but it is certainly very easy to detect them in sulphate of ammonia, cotton-seed meal, dried blood and the like.

b. By mixing his own fertilizers the farmer can perfectly adapt his fertilizer to his idea of the requirements of his land and crop, and any intelligent farmer is the best or only judge of these requirements. That opinions differ greatly as to the best mixture for any special crop will be very evident to any one who compares the composition of the leading brands of fertilizers specially designed for the potato or the onion crop, for instance. The chance to vary his formula and note the differences that result on the same field in the same year is worth not a little to any man who manages his farm "with ancient sinew and with modern art."

c. It is easier for farmers whose land and crops are different, to club together and make an order for fertilizer chemicals large enough

* I am indebted to Dr. E. H. Jenkins, of the Connecticut Experiment Station, for the answer to this question.

to secure wholesale rates, than it is to agree on one or two brands of factory-mixed goods which they will order in considerable quantities.

d. Commercial fertilizers on most farms are not a substitute for manure, but a supplement to it, and it is often profitable to add to the dressing of manure only a single fertilizing ingredient, *e. g.*, nitrogen to give an earlier start, phosphoric acid to favor early ripening, or potash to supply a known deficiency of the soil. This can be done with fertilizer chemicals, not with ready-mixed fertilizers.

e. With ordinary business care in searching the market, buying for cash, buying early before the usual sharp rise in chemicals takes place with the opening of the spring trade, mixing the chemicals on the days when out-of-door work cannot be done, while the help on the farm must be paid for just the same—under these conditions home-mixing has been found by many farmers to pay a large profit. Farming can be successful only when business methods are used in every branch. The competition is close and the profits are small in New England farming, but so they are in every kind of business no less than in farming. The per cent. of really successful farmers is very small, but this is just as true of every other line of business. Careful study of the markets he buys and sells in and that he *may* buy and sell in will generally pay a farmer better than exclusive attention to the production of his crops.

INDEX.

PAGE
Ammonia salts alone 65
Ashes as a fertilizer 186
Beetles, picking them off 148
Bone, Raw 132
Bordeaux mixture, Benefits of 181, 182
" " What to apply with 182
Brevities 183
Bud variation, What is known as 141
Chemical Fertilizers, A talk of use and effects of 178
" " Sufficient supply of 180
Crops, large, wanted, use an excess of plant food 93
Crossing, Difficulty about 159
Experiment Stations 42
Eyes, blind, How to detect 144
" Potato 136
" what they are 136
Fertilizer above or below the seed 79, 187
" Chemical same as manure 133
" Complete 47
" " a maximum crop 56
" constituents needed by land, How to find out 125
" experiments 52
" High-grade 132, 190
" How much may be profitably used 73
" ingredients, Supplying more than crops require, folly 90
" tables 50, 53, 54, 55, 56, 58, 59
" under or over seed pieces, ... 79, 187
" " seed pieces, Difference in favor 82
Fertilizers alone, large crops 63
" best made up different sorts of plant food 132
" character represented in the plant 62
" chemical, A talk with farmers on 128
" commercial, Use of, money spent for food not needed 88
" Farmers should study the science of 132
" different, Effects of 69
" " " Sir J. B. Lawes's experiments 61

PAGE
Fertilizers different, Experiments with 47
" High and low grade 132, 190
" Home mixed 191
" " " do they pay 192
" How money is thrown away on 127
" Increased quantities, effects 70, 95
" " " tables 96, 97
" one-sided, low priced, Harm done by 92
" on variable soil, Effects of different quantities 75
" used by Mr. Minch 37
" *vs.* manures for potatoes 69
Food, Perfect must be supplied 128
Grafting the potato and tomato 185
Handling 145
Hilling up, Objections to 149
Hybrid between potato and alkekengi 185
" seeds not hybrid 185
Land impoverished, Increased quantities of fertilizer 70
" " that needs complete fertilizer, how much to use . . 73
" of the plots 60
" short in nitrogen, use fertilizers with high rate nitrogen 92
" what it requires, How to find out 125
Lawes, Dr. 42
Lime as a preserver 145
" superphosphate alone 65
" to bring up the land 125
" Use of, in the soil 130
Machinery, Digging by 146
Manure, Concentrated and farm, better names 144
" Farm 48
" " and chemical fertilizers, difference 134
" " concentrated 134
" What is 133
Manures, different, Effects of 69
" Mineral alone, large crops 63
Moisture, Method of conserving by trench system 44
Mulch, A new, how prepared 105
" experiments 105
" Straw for potatoes 56
" Valley 105
Nirate of soda alone an ill-balanced fertilizer for potatoes 93
" " " yield of potatoes 93
" " use of, Mr. Harris's criticism 87
" " " " " " reply 91
" " with corresponding supply of minerals 92

PAGE
Nitrate of soda, writers advocating the use of 87
Nitrogen and phosphoric acid needed, buy nitrogen in cheapest and best form 83
" easy to apply top dressing 99
" effect in varying quantities 95
" Effects of 47
" Farmers not to depend upon alone 98
" Gentle and conservative in the use of 95
" its effects when applied alone 87
" not more valuable than potash and phosphoric acid 96
" only for one season 99
" Use blended forms of 93
" used without regard to soil 96
Nitrogenous manures alone, Negative result of 65
Paris green and plaster preferred 148
" " water, Objections to 148
" for potato beetles, Quantity mixed with plaster 84
Phosphoric acid, Effects of 47
Plant growth without moisture 177
Plants require food adapted to their growth 126
Plaster, Causes of variable effects of 186
Poisoning 147
Potash, Effects of 47
Potato balls, why so few 189
" contest, how it came about 15
" " Judges' report 18
" " plot 15
" " " attack of flea beetles 17
" " " notes of progress 16
" " " previous treatment 18
" " result 18
" " second 20
" " " kinds planted 22
" " " yield 22
" " women's prizes awarded 39
" crop, conserving moisture by trench method 44
" " Importance of water to the 43
" cultivation, avoid packing soil 34
" " failures, instructive 20
" " on a larger scale 24
" culture, drought, to guard against 26
" " fertilizers used by Mr. Minch 37
" " in half barrels 100
" " " " preparation of soil, water, etc 101
" " " " yield 102
" " level 33

PAGE
" " Mr. Minch's yield, how obtained 37
" " on small plots, remarks 31
" " yielding medium for growth 33
" Dakota Red, large yield 40
" Everitt, many eyes 122
" experiments at Rothamsted in succession 64
" " barrel in garden soil 100
" " at Rural Grounds, five series 149–182
Potato experiments, barrel in pure sand 100
" " " ¾ garden soil, ¼ sand 100
" " " " " ¼ cut straw 100
" " largest yield 56
" " on different land 52
" " third year's trial on different land 57
" eyes 136
" " blind, to detect 144
" " many, growth of vine 117
" " what they are 136
" fertilizer experiment tables 50, 53, 54, 55, 56, 58, 59
" fertilizers of the day too low in nitrogen 98
" food, ample supply of 179
" growing cramped space for 119
" growth 117
" many-eyed, growth of vine 117
" nitrogen in the juice 67
" " taken up by the plant 66
" number of eyes a guide to planting 117
" to plot, half acre, fertilizers used 25
" " " mulch 27
" " " Nitrogen applied 28
" " " seed pieces 27
" " " yield 28
" " " " of poor soil 26
" plots land of 60
" " which yields most 48
" raising, usual system 119
" seed and stem ends, absurd names 116
" " cut to single eyes, the distance to plant 108
" " cylindrical pieces 112
" " flesh to each eye for profitable crop 111
" " pieces, different number of eyes 110
" " " sizes, different 110
" " " variously treated before planting 102
" " planting 137

PAGE
Potato seed, Selection of 137
" " size determined by number and vigor of eyes 120
" " " of 120, 180
" " whole 111
" " " bad advice 122
" seedlings, care of 138
" skins cut to single eyes 111
" starch in the 67
" tests, difference between small plots and whole fields 35
" " on small areas 34
" tops, analyses of 124
" vines, growth of 155, 160, 166, 169, 175
Potato tops, any injury to decreases the yield 186
" " Immense 60
" tubers, analyses of 123
" yields as indicated by vines 59
" " computing, method 107
" " heavy by trench method 39
" " immense, two enemies 24
" " paying, to test 25
" " Reported, doubts expressed 107
" " startling announcements 14
Potatoes, best yielders 154
" Different fertilizers for experiments 47
" fertilized with snuff 177
" Fertilizer over or under seed pieces 79
" Few-eyed, growth of 117
" from seed 135
" grown in variable soil, effects of different quantities of fertilizers 75
" how much seed to acre 155
" in succession for 16 years 61
" keeping 153
" mulching, a new way 105
" Experiments in mulching 105
" needs, farmer must find out 133
" never mix in the hill 136
" on same soil for 9 years, Dr. Lawes's experiments 93
" " " " " 12 years 64
" planted eight inches deep 84
" " four inches deep 83
" " in four-inch trenches give largest yield 86
" " " trenches of different depth, results 83
" " ten inches deep 84
" quality of influenced by manure used 181

PAGE
Potatoes, what a crop removes from an acre 124
" yield of, nirate of soda alone used 93
Productiveness fixed by selection 141
Seed and stem ends, absurd names 116
" ball from Wall's Orange 136
" balls or fruit 135
" care of 144
" cut to single eye, distanced apart to plant 108
" end vs. stem end 112
" experiments with one piece 108
" " " two pieces 109
" " " three " 109
" " " four " 109
" Exposing it to light and sun before planting 144
" Fertilizer under or over, which 79
" Flesh to each eye for most profitable crop 111
" from productive hills, should we select 140
" how cut 49
" " much flesh to each eye 111
" " prepared 57
" pieces, different number of eyes 110
" " distance apart in proportion to size 113
" " cylindrical 112
" " of potato No. 2 115
" " sizes different 110
" " variously treated 102
" planting 137
" selecting the little tubers for 142
" selections of 137
" size determined by number and vigor of eyes 120
" " " " the variety 115
" skin of the potato 111
" whole potatoes 111
" " " bad advice 122
Seedlings, care of 138
Soil, how to find out what it requires 125
" natural, yield of potatoes 77
" tests not needed 88
" what did it need? 52
" " it needs, how to get at 88
" impoverished, to lash into yielding 126
Straw mulch, how prepared 56
Sulphate of iron harmful 71
Tables 73, 74, 75, 76, 85
Trench, how to prepare 45

PAGE
Trench, method, about our 35
" " advantages of 36
" " effects on of rainfall 36
" " means of conserving moisture 44
" " Mr. Cory's success with 40
" " " " yield 40
" " objections to 45
" " origin of 13
" " trenches 20
" " yield of 40
Trenches, Average yield of the nitrate of soda 176
Tubers from the most productive hills 142
" save only those from most productive hills 143
Valley mulch 105
Varieties from the seed 136
Water for the potato crop 43
Yield, promise as indicated by vines 59
Yields, computing method 107
" large, doubts expressed 107

INDEX TO ILLUSTRATIONS.

PAGE

Mulch, Valley 105
Potato, Blush, long-stemmed 122
" growth without moisture and decay 116
" growths 118
" pit, and how to construct 188
" seed lifted from a trench 117
" seedlings, first leaves 137
" " second leaves 138
" taken from barrel in cellar 118
Potatoes in the hill, ideal 119
" " trench, ideal 119
" " " roots and tubers 121
Seed ball of Wall's Orange potato 139
" piece, one eye only 111
" potatoes, cylindrical pieces 112